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## CONTENTS



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## Heat Insulation for Buildings

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**Paper presented before the Hamilton Branch of The Engineering Institute of Canada, November 17th, 1936.**

SUMMARY.—This paper outlines the methods of testing heat-insulating materials and discusses the various factors which affect the accuracy of the results obtained. These include such points as the dimensions of the specimen tested, the mean temperature of the material, its moisture content, its density, thickness, liability to disintegrate and permeability.

The importance of heat insulation, in general, has been known for many years, but its advantages, as applied to industrial and residential buildings, are only just beginning to be appreciated by the public. A pamphlet issued by the Dominion Fuel Board in 1927 indicated that a fuel saving of thirty million dollars per annum was possible if all residential buildings in Canada were properly insulated, and that the savings in Montreal, Toronto, Hamilton and Ottawa alone would be about seven million dollars every year.

Research work on this problem has been proceeding for a number of years at the University of Toronto under the auspices of the School of Engineering Research, to establish the relative values of the materials offered for this purpose.

Various figures, given by salesmen and advertisers, are supposed to indicate the relative merits of such materials, but the principal trouble is that frequently the test results quoted cannot be compared with each other because the methods of testing are different, and the sizes and conditions of the specimens used vary considerably. In many instances, also, the information given is so incomplete that the test figures, while correct in themselves, give very misleading comparisons. For example, the size, thickness, density, moisture content and other similar factors, have considerable influence on the results obtained, and a figure that is correct for a small, thin specimen does not always apply to a large, thick sample. Also, the sample tested might not be a representative one.

The various forms of insulating material may be divided into rigid, filler and blanket types, which derive much of their value from the air spaces contained in them and those which depend largely on the use of bright metallic surfaces. Each of these has its advantages, and there is no one material that gives the best results under all conditions. The best insulating material is that which gives the greatest resistance to the transmission of heat per dollar expended, taking into account the cost of material, the cost of applying it to the structure and the rate of depreciation. Resistance to the action of fire and vermin and to the penetration of air must also be considered.

A survey of some two hundred homes, in 1928, indicated that, on the average, about 16 per cent of the heat was lost through the roof, 27 per cent through the walls, 26 per cent through the windows, 25 per cent by air leakage, and the rest through doors, floors, etc. With various methods of insulation and the addition of weather stripping and storm sashes, the possible reduction of heat loss varied from 13 to 35 per cent, under different conditions, and in one case it was estimated to be as much as 66 per cent, but this was unusually high. This survey indicates that other factors beside insulation enter into the question of fuel economy, and if attention is concentrated on insulation only, the actual saving may be less than it should be.

### PRINCIPLES OF HEAT TRANSMISSION

Heat is transmitted from one fluid to another by conduction, convection, radiation, or by a combination of any two or all three of these. The amount of heat transmitted through an insulating material is generally expressed as the number of British thermal units passing per hour through a square foot with a one degree temperature difference held between the two faces. This is called the conductance "$C$" of the material, and its reciprocal is known as the resistance "$R$." The conductivity is usually calculated by multiplying the conductance "$C$" by the thickness in inches "$x$," but in the author's opinion, this name is badly chosen, as the true conductivity of the material obviously remains constant with different thicknesses, whereas it will be shown later that the conductivity "$k$," when calculated in this manner, varies with different thicknesses. The latter, therefore, is a characteristic of the specimen and not of the material, and so it is preferable to call this property by some other name, such as "apparent conductivity."

In addition to the resistance of the solid wall, there are also, in practice, the resistances of two air films on the inside and outside, respectively. The thicknesses of these depend on the direction and velocity of the air, and for this reason, high air velocities cause the amount of heat transmitted to increase. The total resistance to the transmission of heat is the sum of all the individual resistances and, therefore, there are two ways of determining the resistance to heat transmission, namely, by testing a section of the actual wall, or by adding together the resistances

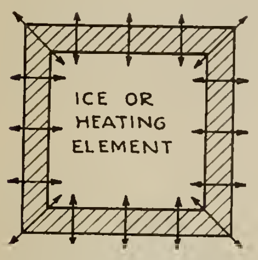


**Fig. 1 —Simple Hot or Cold Box made entirely of Material to be tested.**

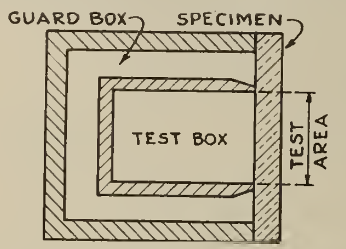


**Fig. 2—Guarded Hot Box. The Guard Box and Test Box are kept at the same temperature by Electric Heaters and Fans.**

of the various materials of which the wall is composed. Thus

$$U = \frac{1}{\frac{1}{f_1} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \ldots \frac{1}{f_2}}$$

where $U$ is the "air to air" coefficient of heat transfer for the wall,

$f_1$ and $f_2$ are the conductances of the air films,

$\frac{x_1}{k_1}, \frac{x_2}{k_2}, \frac{x_3}{k_3}$ ..... are the resistances of the various sections of the wall.

### Methods of Testing

(1) *Hot Box Method*

The specimen forms one side (or all sides) of a box, the others being composed of highly insulating materials, the heat transmissions of which are known. By using thermometers or thermocouples and heating the inside of the box electrically, it is possible to calculate the amount of heat that passes through the specimen while maintaining either definite air temperatures on each side of the wall or a definite temperature drop between the two surfaces. This method, however, is cumbersome and expensive. It is difficult to obtain even conditions over the whole surface of the specimen, and a long wait is necessary before conditions become sufficiently steady for readings to be obtained. In some cases, two boxes are used, one inside the other, the outside box being kept at the same temperature as the inside so that heat losses are suppressed from all surfaces save that used for testing. (Figs. 1 and 2.) This is still more difficult to control and is a good deal more expensive to construct. In such cases also, if a composite specimen is used, the quality of the workmanship used in constructing the specimen influences profoundly the final result, so that a good deal of uncertainty may be expected. However, tests made in this way are useful for checking purposes. It is usually preferable, wherever possible, to test the materials themselves and to use the figures thus obtained as a basis for calculating the heat transmission from "air to air."

(2) *Hot Plate Method*

In this case, two similar specimens are employed, and these are sandwiched between a central plate that is electrically heated, and two cold plates kept at the required temperature by circulating through them water or cooled brine. (Fig. 3.) The temperatures of the hot and cold faces, respectively, are indicated by thermocouples, and losses from the outside edges of the specimens are avoided by the use of a sufficient thickness of insulation or, alternatively, by using a guard ring; the latter is in the form of a hollow square wound with resistance wire and a current is passed through it sufficient to keep the outside edge of the specimen at the same temperature as the central part which forms the actual test area. (Fig. 4.) The author believes that use of the guard ring, in the case of mean temperatures less than 100 degrees F., is unnecessary and may be undesirable, because if the guard ring is not kept consistently at the same temperature as the centre of the specimen, greater errors may be introduced than when no guard ring is employed. Tests have been made by him with simple plates, adequately protected around the edges by 3½-inch cork board, and in no case has it been found that appreciable errors have resulted from the elimination of the guard ring, even in the case of thick specimens where the errors may be expected to be greatest.

The sizes of these plates vary from 8 inches by 8 inches to 30 inches by 30 inches, and in some cases, even larger plates have been designed, but the larger the plate, the more expensive it is, the more difficult it is to keep conditions constant over the whole area, and the longer is the period required to make a representative test. There is some evidence that the size of the plate used may have an influence on the results obtained, particularly in cases where it is possible for air movement, or convection currents, to be set up within the specimen. When specimens ½ inch thick were tested in hot plates 8 inches and 24 inches square, respectively, the same results were obtained, but when larger and thicker specimens were tested, higher apparent conductivities were obtained with the 24-inch plate as compared with those from specimens one inch thick tested in the 8-inch hot plate, as follows:—

| | |
|---|---|
| Rock wool and glass wool..... | 2 inches thick, increases 40-60 per cent |
| Metal foil, crumpled.......... | 2 inches thick, increases 65 per cent |
| Fibre board.................... | 2 inches thick, increases 24 per cent |
| Packed materials............. | 4 inches thick, increases 70-90 per cent |

It is not clear what part of this increase is due to the larger size of plate, as it was impossible to test the thick specimen in a small plate on account of the large edge losses that would be obtained. It is probable, however, that a good deal of this difference, if not most of it, is due to the increased thickness.

### Thickness of Specimen

With the modern tendency towards the use of thick insulation, there has arisen a demand for tests to be made

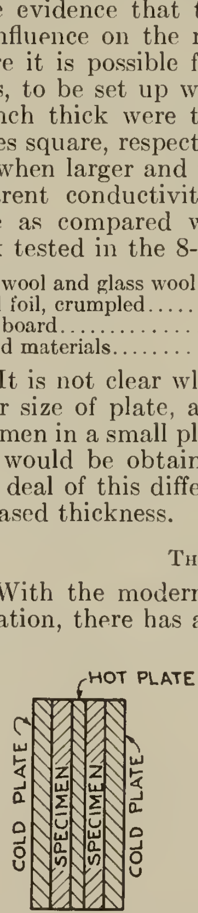


**Fig. 3—Hot Plate Apparatus.**

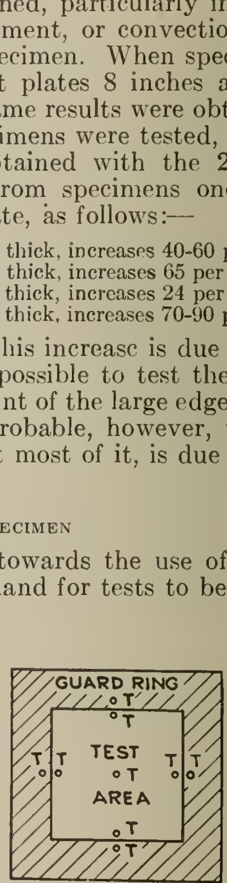


**Fig. 4—Guarded Hot Plate. Thermocouples are Indicated by "T."**

on specimens 2 inches and 4 inches thick, and the apparatus and technique that were apparently suitable for the old conditions do not seem to be readily applicable to the thicker and more highly resistant materials that are now being employed. Experience, both at Toronto and elsewhere, has indicated that the "apparent conductivity" of insulating materials (except in the case of cork board) increases with the thickness, and the form of curve appears to be fairly definite, but the following characteristic figures for fibre boards indicate this effect:—

| Thickness | "k" |
|---|---|
| ½ inch | .38 |
| 1 inch | .41 |
| 2 inches | .44 |
| 3½ inches | .48 |

In the case of rock wool, it has been found that 2-inch and 4-inch thicknesses give apparent conductivities which

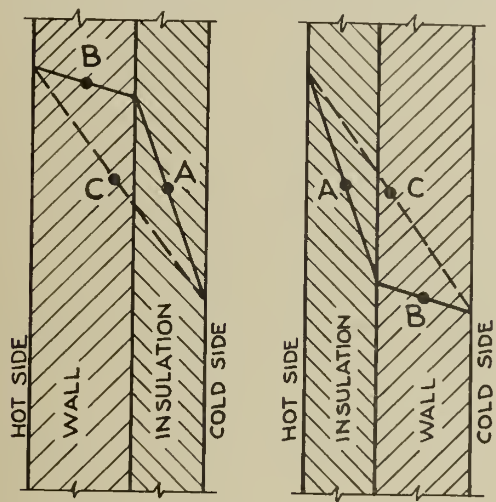


**Fig. 5—Full Line—Actual Temperature Gradient.**
**A—Mean Temp. of Insulating Material.**
**B—Mean Temp. of Building Material.**
**C—Mean Temp. of Structure.**

are 25 and 35 per cent higher, respectively, than those obtained with a thickness of one inch. Similar observations apply also to glass wool and many other substances. In the case of fibre boards and other similar materials, it is probable that surface resistance plays a large part in producing this effect. The author found by embedding thermocouples within cast material, that there was a definite resistance to the passage of heat through the surfaces of the specimen, and other investigators have made similar observations. In the case of packed materials, the situation is somewhat different, but it has been found recently that there is definite evidence of the circulation of air within these materials, and it is quite possible that the amount of heat transmitted in this way may increase materially as the thickness increases. It is possible, also, that radiation may play some part in the operation, but this is not certain.

In some instances, thick materials are being used for the purpose of storing heat and producing a kind of thermal flywheel. This may be very useful in cold weather by evening the heat load and perhaps by storing solar radiation, but sometimes it has been found difficult to control in hot weather when the amount of heat stored was liable to produce undesirable effects.

### Pressure on Sample

Tests have shown that the superficial pressure on the sample of material being tested has no influence on the result, provided that specimen itself is rigid.* Packed or "fill" materials are usually enclosed in a box, so that in this case the question of compressibility does not arise. With soft materials, however, which are tested in the form of a mat or blanket, the pressure must be carefully controlled, as increased pressure both reduces the thickness and increases the density of the material. The calculated value of the apparent conductivity, therefore, may be affected very considerably. A suitable pressure for this purpose would be about 45 pounds per square foot.

*"Heat Insulation as Applied to Buildings and Structures," by the author. Proc.I.Mech.E., December 1934.

### Mean Temperature

The mean temperature of the specimen is usually considered to be the arithmetic mean between the temperatures of the hot and cold faces, but it does not necessarily follow that this will be true in practice, as, with thick walls, and particularly in cases where thick insulation is used, the temperature gradient through the material is seldom a straight line. Further, if different materials are used in series with each other, the slopes of the various lines that represent the temperature gradient will change materially (Fig. 5) and therefore, as far as possible, the apparent conductivity of the material, at the appropriate mean temperature, should be employed in calculations.

If the apparent conductivities of various materials used for insulating purposes are plotted against mean temperatures, it will be found that for temperatures below 100 degrees F. these relationships are not only represented by straight lines, but that the lines themselves are very nearly parallel to each other. (Fig. 6.) The following formula may be used without serious error to indicate the apparent conductivity at a temperature "$t$" when the conductivity at a standard temperature of 50 degrees is known.

$$k_t = k_{50}\,[1 + .0024\,(t - 50)]$$

Similar formulae may be calculated for other standard temperatures. The standard mean temperature of 50 degrees F., which was agreed upon some years ago by a Committee of the National Research Council of Canada, is taken midway between an inside temperature of 70 degrees F. and an outside temperature of 30 degrees F., as these were considered to represent approximately average Canadian conditions. However, this mean temperature is rather awkward to handle, as, if the cold plate employed is at a low temperature, there will either be trouble owing to the formation of ice on the cold side, or, if the temperature is too high for this, the test material may become very wet on the cold side due to condensation of moisture from the atmosphere. On the other hand, if a high mean temperature is standardized, the temperature of the hot side of the specimen may become excessive, and the possibilities of serious heat loss to the atmosphere are increased. The

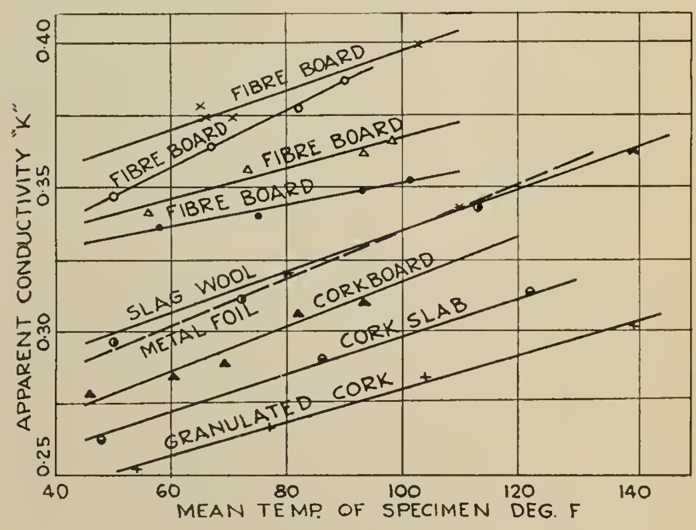


**Fig. 6—Effect of Mean Temperature on Test Results.**

author is of the opinion, therefore, that for general use, a mean temperature of 75 degrees F. represents the best compromise. In this case, the hot plate should be at about 95-100 degrees F., which is not too high for practical use, and the cold plate temperature at approximately 50-55 degrees F., which is usually obtainable without serious difficulty. In some cases, indeed, the water available in the town mains is cold enough for this purpose, and therefore the constant use of a refrigeration machine may be unnecessary, but then, some provision must be made to deal with the question of temperature fluctuation which sometimes gives considerable trouble.

### Temperature Difference

The difference of temperature maintained between the hot and cold sides was formerly considered to be unimportant, provided that a definite mean temperature was used. Tests made by the author confirm this, provided

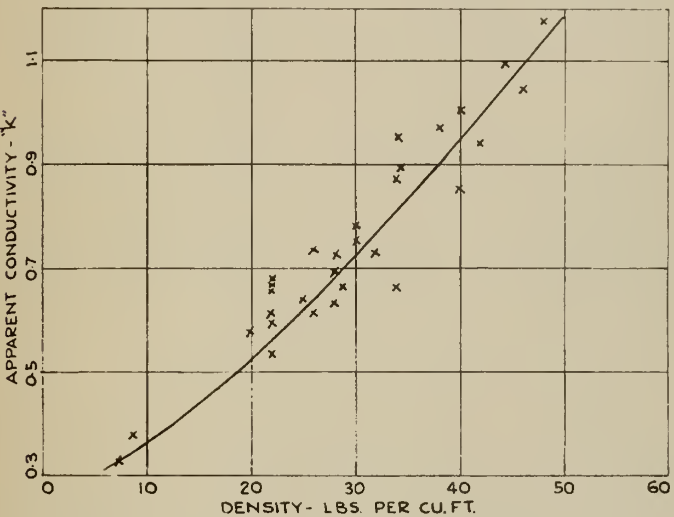


**Fig. 7—Test Results on Dry Timber (Mean Temp. 75 degrees F.)**

that thin specimens are employed, as with specimens of fibre board one-half inch thick and temperature differences varying from 30 to 80 degrees F. no significant differences were obtained in the calculated conductivities. When thicker specimens were employed, however, very considerable differences were noted, and in general, it appears that the apparent conductivity increases with the temperature difference. This may possibly be due to changes in surface resistance, internal convection, radiation, or combinations of these factors. Whatever the causes may be, it is evident that the temperature difference should be standardized as well as the mean temperature. If the temperature difference is small, errors of measurement become comparatively large, and therefore it is suggested that a standard temperature difference of about 40 degrees F., as indicated in the previous paragraph, will give comparable results without involving excessively high or low temperatures.

### Moisture

For research and experimental purposes, it is advisable that tests should be made on specimens that are in a dry condition and the committee referred to above, decided that specimens should be heated to 140 degrees F. and kept at that temperature for twenty-four hours before any tests were made. This temperature was decided on because certain materials underwent structural changes if higher temperatures were employed. In practice, however, the materials actually used sometimes contain considerable amounts of moisture and this may increase the heat transmission through them to a very considerable extent. Of the materials commonly used, glass wool and rock wool contain practically no moisture when received. Cork board contains about ½ to 1 per cent by weight, and fibre boards from 5 to 8 per cent. When exposed to air at 70 degrees F. and 85 per cent relative humidity, no increase in weight took place in the glass wool or rock wool; cork gained by one per cent and fibre board by ten per cent. Thus, in the case of fibre boards, for example, the final moisture content by absorption from atmosphere may be as high as 17 or 18 per cent when estimated on the basis of dry weight. If air infiltration and condensation occur, as when conditioned air is cooled below the dew point, the material may become waterlogged and then will contain many times its own weight of water. The seriousness of this condition is indicated by the fact that the heat conductivity of liquid water is about twenty-four times that of the vapour, and that of ice is about ninety times that of the vapour. The practical disadvantages are obvious.

It is evident, therefore, that the question of the conductivity of those materials which contain various percentages of moisture, deserves further study, but the difficulty is to find a way of distributing the moisture evenly through the specimen and keeping it there while the test is being made. It is a matter of common experience that when a specimen is tested in the hot plate, some of the moisture is evaporated, and even if this does not occur, the moisture tends to leave the hot side and to travel towards the cold side of the specimen. This effect was examined by making a specimen of fibre board 3½ inches thick in two parts which were, respectively, 2 inches and 1½ inches thick. The density of the boards on the hot side decreased during the test from 15 to 14.8 pounds per cubic foot, while that of the boards on the cold side increased from 16.3 to 16.7 pounds per cubic foot. The total density of both boards showed no change, so that in a solid specimen there would be no evidence of loss or gain of moisture, but the condition of the specimen after the test would be different from that before the test. It is possible that some new type of apparatus may have to be devised for making tests of this kind, but in the meantime, tests must be made on specimens containing no moisture, or very little; otherwise, erratic results are likely to be obtained.

### Density

As a general rule, and particularly in cases where solid materials rely for their insulating value on the air cells contained within them, the conductance of materials increases with their density (Fig. 7), but this is not always true. The use of fibrous materials, particularly those that are packed into large air spaces, has introduced materials of very low density. In these cases, it is found that if the density is reduced below a certain value (usually between 2 and 6 pounds per cubic foot) the heat transmitted through the specimen increases. (Fig. 8.) This may possibly be due to the greater facility afforded for the circulation of air within the material; but it is also possible that radiation plays some part in this phenomenon. Recent experiments

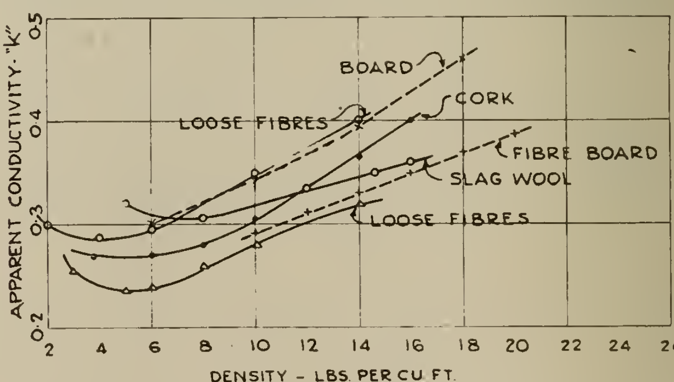


**Fig. 8—Effect of Density on Heat Conductance of Insulating Materials.**

made at the University of Toronto give distinct evidence that movement of air does occur in material packed to a density as high as 10 pounds per cubic foot, and thus some transfer of heat by convection is bound to take place. A specimen 24 inches square and 4 inches thick was tested in the usual way, and was then divided into horizontal layers, each 2 inches wide, by means of paper partitions. It was found that the plain specimen, which gave unrestricted movement of the air, had an apparent conductivity with 40 degrees F. temperature difference, exceeding by 50 per cent the corresponding figure for the divided specimen. Decreased density in such materials reduces the number of contacts between the solid fibres, and therefore decreases the probable transmission of heat by conduction. It appears, therefore, that, in addition to the size and composition of the fibres themselves, their arrangement will have a considerable influence on the results obtained. It is possible that some such studies will have to be undertaken in connection with the structure of heat insulating materials as have been conducted in metallurgical work in connection with the structure of metallic materials. There, it is found that not only the composition, but also the arrangement of the materials has a very considerable influence on the results obtained. It seems probable to the author that similar factors affect the heat transmission of insulating materials, and that some kind of classification may eventually be undertaken that will indicate the most desirable characteristics of such structures. Thus, not only the quantity of solid material present, but also its arrangement, is likely to be important.

### Surface

The fact has been known for many years that the amount of heat transmitted by radiation from a bright surface, and absorbed by it, is very much less than it is in the case of a dull surface. This fact has been utilized in some of the recent materials which rely upon metallic surfaces for the purpose of transmitting, or impeding the transmission, of radiant heat. The effectiveness of these surfaces depends upon their emissivity, which indicates the percentage of radiant heat reaching the surface that is absorbed and transmitted by it; thus, aluminium has an emissivity of 5 per cent, which means that 95 per cent of the radiant heat received by the material is reflected from it. Iron has an emissivity of approximately 10 per cent, and tin of about 20 per cent, so that these materials are less effective in the sense that they transmit more radiant heat than does aluminium.* It is to be noted that the wave length of the heat radiated has an influence on the emissivity, the latter becoming less as the wave length increases. It must also be noted that the value of such materials depends on their surfaces, and therefore that if these are obscured by dust, corrosion, moisture or frost, the amount of heat radiated from them is likely to increase materially. Possibly corrosion may be prevented, either wholly or partly, by the use of some protective covering, but in that case the emissivity may be seriously increased. Dust may be avoided by sealing the insulation against air infiltration, but this procedure is sometimes expensive.

There are three ways of applying these materials: The first is to stretch them across the centre of an air space, thus forming a number of parallel surfaces. This is probably the most effective method from the standpoint of heat insulation. Metal foil is sometimes crumpled and used to fill an air space loosely. This is less effective than the former method, but is cheaper and appears to give good results. The third method is to use it to coat one or both sides of a rigid board, in which case the advantages of both materials are combined. These metallic sheets, in themselves, are not effective barriers to convected heat, and therefore it may be necessary to combine them with some other material that will provide such a barrier.

Such materials, used in thin sheets or as foil, cannot be said to have any conductivity or conductance, as their effect is obtained by combining them, either with the insulating value of one or more air cells, or, alternatively, by using them to coat some other material. Comparisons, therefore, must be made on the basis of the conductance of the structures and not on the conductances of the various materials concerned.

*See "Heat Ray Traps," by Shadgen, "The Iron Age," Feb. 14, 1935. Other figures are given by McAdams in "Heat Transmission" (McGraw Hill).

### Air Spaces

Air is a most efficient insulator provided it can be kept still, and in most of the materials considered above, the air is prevented from moving by entangling it between fibres or enclosing it in small cells. A large air cell can also be used for insulating purposes. As the thickness of the large air cell increases, the amount of heat transmitted through it by conduction decreases on account of the longer path that the heat has to traverse; but that lost by convection is liable to increase because of the lower frictional resistance offered to the circulation of the air. Experiments made by Rowley and Algren at the University of Minnesota, show that the resistance of an air cell 9 inches square increased with its thickness up to about .8 of an inch, but beyond that no further improvement took place. The best results, therefore, are obtained by using air cells that are about three-quarters of an inch thick. In some cases, where metallic insulators are used, it may be advisable to pack more of these materials into a given space, so that the overall dimensions may be reduced.* It is probable that the heat transmitted through an air cell varies with its height as well as its thickness, and therefore it is advisable to keep the height as small as is economically possible. The heat transmission also increases, as might be expected, with the temperature difference across the cell.

In many instances, considerable advantage is obtained by using powdered or granulated materials for the purpose of filling up air spaces and preventing, as far as possible, the formation of convection currents. If the height of the air cell is large, very considerable densities may result, owing to the weight of the material itself, and occasionally vibration causes the material to settle or pack some time after it has been installed, so that the top of the air space is left empty. However, properly applied, such devices can be quite effective.

It has been suggested that a vacuum, such as is employed in thermos flasks, might be useful for insulating purposes, but experiments made many years ago, indicate that, unless extremely high vacua are employed, this method is not effective. If air spaces are used they should be sealed, as far as possible, to prevent air infiltration as, otherwise, moisture is very liable to be deposited in them, causing considerable trouble and loss of insulating value.

### Conclusions

The foregoing arguments may be summarized briefly as follows:—

(A) *Factors that should be Standardized*
- (1) Design of apparatus and testing methods.
- (2) Size of apparatus in relation to the thickness of material tested.
- (3) Mean temperature of material tested.
- (4) Temperature difference to be maintained between hot and cold surfaces.
- (5) Pressure to be applied to specimen when testing (in some cases).

(B) *Factors that should be Listed in the Tables giving the Thermal Conductivities of Insulating Materials.*
- (1) The conditions under which the tests were made, e.g., air to air, or surface to surface. In the former case the velocity, temperature and relative humidity of the air may be important.
- (2) Moisture content of the material when tested.

*Usually about three sheets per inch of thickness are employed.

(3) Density of the material when tested.
(4) Thickness of specimen tested.

(C) *Factors that Affect the Method of Installing Insulating Materials.*
(1) Permeability—particularly when air conditioning is employed.
(2) Possibility of the absorption of moisture or its deposition on a reflecting surface.
(3) Size and shape of air spaces used.
(4) Effect on total heat loss, of other materials used in the structure which have high conductivities.
(5) (Possibly) structural strength or other physical properties of the insulating material, e.g. liability to disintegrate.

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# Recent Advances in Electric Welding

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**Paper presented before the Montreal Branch of The Engineering Institute of Canada, December 3rd, 1936.**

**SUMMARY.—Discusses the two main types of electric welding, noting first the trend of practice in arc-welding and the adoption of special electrodes for use with alloy steels and sheet steel. Notes follow on the development of various types of resistance welding, particularly as regards electronic control of timing in spot-welding.**

Electric welding comprises two major processes, the arc and the resistance methods; these have only two points in common, first, that metals are fused together, and second, that electricity is the heating agent.

Of the two, arc welding is the better known, and has received more attention than has its less spectacular but equally effective rival. If any proof of the increasing use of arc welding is desired, it is found in the fact that last year some 40,000 tons of electrodes were used, indicating a production of between two and three million tons of weldings.

An outstanding recent development has been the almost complete change to covered electrodes from the older bare rods, and the standardizing of the newer rods into three distinct classes, each with its clearly defined field.

The first class, both in quality of resultant deposit and in time of origin, is the downhand type of electrode, so called because it can only be effectively used in a downhand position placing the metal into a butt weld groove or into a troughed position fillet.

This class of rod produces the highest quality metal, particularly in terms of ductility and density. Generally speaking it is the only type that will pass the tests specified for welds used in the production of high grade pressure vessels or power boilers.

The second type has been developed for the production of high grade, good appearing fillet-welds without the necessity of bringing the weld into a downhand troughed position. These produce extremely good looking fillets; the metal has a somewhat higher ultimate tensile strength and yield point than that from the downhand rods but is inferior in ductility and density averaging 20 to 25 per cent elongation in 2 inches with 25 to 30 per cent reduction in area on all-weld-metal specimens combined with a yield point of 50,000 to 60,000 pounds per square inch and an ultimate strength of 65,000 to 75,000 pounds per square inch.

In the third class of electrodes are the well named all-position rods which differ from the fillet-weld types in that they may be used in any position, including vertical and overhead. The physical properties of the resultant metal are similar to those for fillet-weld rods. This type was the second to be developed and at that time was of great importance in that it covered the field which it now divides with the fillet-weld rods.

Table I
Physical Properties of Arc Weld Metal Deposited from

| | Downhand Rods | Fillet Weld Rods | All Position Rods |
|---|---|---|---|
| Ultimate tensile.......... | 64,890 | 75,705 | 64,630 |
| Yield point.............. | 48,925 | 61,025 | 48,410 |
| Elongation in 2 inches.... | 33.0 per cent | 24.0 per cent | 30.0 per cent |
| Reduction in area........ | 65.8 per cent | 46.4 per cent | 56.0 per cent |

### The Trend of Arc Welding Design

A great many developments go from one extreme to the other and then follow a middle course. The early attempts at designs for arc welding tried to duplicate the appearance of the article as previously built by other methods. Later, designers began to forget casting appearance and design for function. Thus an era was entered upon when weldings were distinguished by square corners and crude box like structures even though utility was, for the most part, well provided for. This phase is rapidly passing, as a result of careful design studies having the triple objective of greater utility, better appearance and lower costs. The most successful means has been a combination of bending and butt welding in preference to corner welds, reducing the amount of welding, which as far as possible is of the superior butt weld form.

Rectangular transformer and circuit breaker tanks are a simple but good illustration, using two shallow "U" sections with butt welding in the sides permitting uniform radii at all corners in preference to the former bend two and weld two corner system.

In the manufacture of small machine parts, it was more difficult for arc welding to replace castings, due to low weights, and the ease of casting with low pattern cost. In the case illustrated, that of bedplates for small motors (see Fig. 1), the advantages of all steel construction combined with good appearance and moderate costs have been attained by a combination of bending and welding. The main member has four slots and four foundation bolt holes punched in it, it is bent into the form of a flanged "U" and the two end straps are welded on to complete the job. An adjustment device and bolt-holding strap may be added if desired.

The same combination is successfully used in bedplates for large machines by combining "U" shaped main members, half mitered at the corners, with a hot formed corner piece, into a nice appearing unit of moderate cost using nothing but stock plate, so that there is no need either to stock or wait for suitable structural shapes. Reinforcing ribs, foundation bolt plates and machine pads may be placed wherever desired.

Another example would be the end treatment of large I or H beams by cutting the web and flanges and welding on a formed plate to continue the upper flange around the end to meet the lower flange.

End bells for a large pump motor form another example of the recent trend (see Fig. 2). In this case each half section was formed cold in four sections under a hydraulic press, butt welded together and the welds ground off to match the customer's previously installed equipment.

The mere mention of grinding welds is likely to provoke discussion. As a general rule, the author is strongly opposed to grinding welds on the ground that there is a danger of hiding inferior work, but in the manufacture of electrical equipment there are cases where it should be done to create

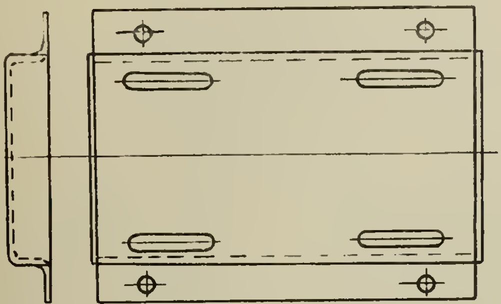

**Fig. 1—Bending and Welding Combined to Produce Substantial Bedplate.**

harmony with the highly finished equipment frequently found in power houses.

A striking recent advance in the field of arc welding has been the development of the so-called high-strength low-alloy steels. These have less than 5 per cent of alloying elements, hence the term "low alloys," but this results in remarkable improvement in their physical properties with tensile strengths of 70,000 to 100,000 pounds per square inch with yield points of 50,000 to 70,000 pounds per square inch compared to the 30,000 to 35,000 yield and 45,000 to 55,000 per square inch ultimates of the ordinary low carbon welding quality steels. These newer steels all possess satisfactory bending and impact strengths and one in particular, a three per cent nickel steel, is useful for low temperature service. In every case these steels were developed with an eye to their weldability, and having a low carbon content, full strength sound welds can readily be made. The effect on welding design is only just beginning to be felt, but results in lighter structures. The material-handling equipment firms are using these steels to advantage; one company in re-designing a drag-line bucket removed 1,000 pounds of dead weight and thus increased pay loads. Another took 1,635 pounds off a coal truck body that previously weighed 5,000 pounds. Therefore the designer can well afford to keep in touch with developments in welding.

The use of stainless steels of the austenitic 18-8 class (18 per cent chromium, 8 per cent nickel) has been greatly facilitated by the ease with which they may be arc welded. The only real problem is to ensure against carbide precipitation adjacent to the welds with the accompanying lessened corrosion resistance. Specifying a carbon content of under .08 will prevent this trouble. In the actual welding of the material to itself a covered electrode of slightly higher alloy content, of about 20 and 9 is used, with 20 per cent less current than for a mild steel rod of the same size. The metal is extremely fluid while passing through the arc, thus requiring somewhat better assembly fits than for mild steel work.

Having an austenitic structure, 18–8 is necessarily non-magnetic, and as such is used in the electrical industry as "no-mag" inserts to break up magnetic circuits. This involves welding it to mild steel. If an 18–8 type rod is used, dilution from the mild steel side produces a brittle martensitic structure and to use a mild steel electrode produces the same results by alloy pick up from the stainless steel. Either procedure causes cracked welds from contractional stresses within the brittle weld metal.

These difficulties are overcome by the use of an electrode having such an excess of alloys that dilution from the mild steel side does not bring the weld below the 18–8 analysis. It has been found that a 25-12 (25 per cent chromium, 8 per cent nickel) electrode will do this and produce excellent results with no other changes in technique from standard stainless welding practice.

### Medium and High Carbon Steels

Until recently medium and high carbon steels presented a difficult problem to the welder, but where the weld can be made from a non-hardenable deposited metal excellent results have been obtained by using a new type of heavily covered rod that deposits metal having a carbon content of .08, nickel .85 and molybdenum .50, and taking care not to unduly heat the base metal. This method has even been used to weld high speed steel to low carbon shanks and to weld together broken broaches and reamers.

### Weld Testing

Many tests have been devised for testing steel in its various forms, including tensile, compression, bending, impact, hardness and fatigue resistance tests. To these must be added those of chemical analysis, microscopic examination, macro etching, and determinations of specific gravity.

All of these methods are used in developing welding processes and applications, but before evaluating these testing methods it is well to analyze some of the reasons for testing welds.

**Fig. 2—End Bells for an Electric Motor.**

(*a*) Test of joint design.
(*b*) Test to determine the quality of the deposited metal resulting from the use of a particular electrode.
(*c*) Test for the efficiency of a given operating technique, i.e., amperage, voltage, etc.
(*d*) Test to ensure that the operator can and is producing sound welds under the given conditions.

The first three of these tests should be completed and definitely specified before any welded articles are produced.

though they are always a subject for study and improvement.

Joint design has been carefully studied and whenever standard types are used there is little need for tests on this account. Where a special design is required the tests should be carefully made, particularly if the joint is subject to shock or fatigue.

In testing for the quality of metal deposited by a given electrode the service requirements will practically specify the tests to be made and the same is true of tests for technique.

Fig. 3—Fillet Weld Testing Fixture with Weld in position for Breaking.

Testing to determine the quality of the work produced by an operator is often handled in a haphazard manner or is not done at all. This attitude is largely the result of too much reliance on one test, that for tensile strength.

In many cases tensile tests have been made on two pieces of plate welded together and pulled, and the usual results were failures of the parent metal at some distance from the joint. This simply indicated that the parent metal had a lower yield point than the weld metal, hence yield started at some point in the parent stock and continued to ultimate failure at that point, though it was quite true that the joint did withstand the quoted strain.

This stressing of tensile values was unquestionably developed in the old bare rod days when that was the only quality worth speaking about and nobody wanted to talk about impact values or ductility.

The test that should be made of an operator's work is one that will reveal the degree of fusion and the presence or absence of slag inclusions and gas pockets. Fortunately, such tests are easily made. In butt welding, it is the nick break in which a section of a joint, one to three inches wide, is nicked with a saw or gas torch at the ends of the weld and then struck a sharp blow with a steam hammer while resting on vee blocks, so that it is broken through the weld. The break is therefore through any defects and lack of fusion, slag or gas pockets are instantly visible.

A similar test for fillet welds consists in two pieces of material placed together in the form of a tee with a weld made on one side of the vertical member only. The weld is then broken by sledge hammer blows.

Figure 3 illustrates a fillet weld testing fixture with a weld in position for breaking. In training welders every fillet weld is broken by the student welder to ensure that he obtains a sound knowledge of the internal conditions within his welds.

Any welder that can pass either of these two simple tests can produce first-class work since he has done all that a welder can do, in that he has deposited metal of the required soundness in the required manner and place.

First class fillet welds are shown in Fig. 4, clean uniform structures with a complete absence of slag and gas inclusions combined with full fusion should be noted.

Figure 5 illustrates the product of untrained operators and the failure to get root fusion or to fuse the upper to the lower layers, and the large number of slag holes and gas pockets should be observed.

The welder has little, if any, control over such factors as ductility, impact or tensile strength except as they are affected by the soundness or otherwise of the metal deposited. If his weld is free from gas pockets, slag inclusions and has full fusion he has done all that he can. The other qualities are up to the management and are functions of electrodes, equipment, procedure and design.

Tests made to evaluate the quality of an electrode or technique are more elaborate and should always begin with one for soundness of the deposited metal and the degree of fusion since failure to pass this test condemns the rod or procedure immediately. The test earlier outlined for testing an operator is a good one to begin with, but always have a first-class operator make such special tests. Should this first test be passed and further information be desired a bend test will be in order, and may consist simply of a bead welded along a bar and bent. An electrode capable of giving 30 to 35 per cent elongation of the outer fibres will bend through 180 degrees on the simple bend test with a radius of bend equal to half the thickness. This test will not give the percentage elongation. If this is desired it may be obtained from all-weld-metal specimens or from a butt weld in which the surfaces are machined, after welding, lightly etched to reveal the edges of the weld, the width of the weld measured and recorded, the specimen bent through the weld, again measured and the percentage elongation calculated.

Whenever an electrode meets the tests for soundness of deposit, shows good bend test values, combined with

Fig. 4—Samples of Tested First Class Welds.

satisfactory appearance and operating characteristics it will be satisfactory for general mild steel applications. If tensile values are designed, tests on an all-weld-metal specimen is the best method.

The simple test in which two pieces of bar or plate are joined together and then tested has little value since the parent stock usually breaks well away from the weld and gives no information at all except the ultimate strength of the bar, or if the weld does break it is almost always due to poor welding which a simpler structure test would reveal. In any case no information is obtained on yield points, reductions in area or percentage elongation, all of which are necessary to determine the quality of a metal.

The all-weld-metal test alone will give this data. Such tests are made by machining the specimen from a butt or fillet weld purposely made large enough to permit of the entire specimen being obtained from weld metal only.

**Fig. 5—Welds Produced by Untrained Operators.**

All physical properties listed in this article were obtained in this manner.

### Arc Welding Light Sheet Steel

An outstanding recent development has been the use of arc welding in the fabrication of parts made from light sheet steel resulting in higher quality and at greater speed than was heretofore thought possible. Most of the applications so far have been on 18 and 20 gauge material with successful welds obtained on 28 gauge.

The major applications so far have been on food compartments for electric refrigerators, range ovens and similar parts, most of which are subsequently vitreous-enamelled. This greatly complicates the welding problem since the presence of any voids or foreign matter in the welds prevents successful enamelling. Nevertheless the experience on white enamelled food compartments is that less than one per cent have any defect over the welds even though the welding is done at speeds of from 22 to 23 inches per minute.

These remarkable results are obtained by the use of a super-imposed high frequency current in a welder using 25- or 60-cycle current stabilized by the super-imposition of a 100,000-cycle carrier or stabilizing current whose only function is to maintain the ionized condition of the arc gap during the period of current reversal. Some means of retaining the ionization is necessary, since it only exists for about twenty-millionths of a second after the currents have dropped below the minimum required to maintain it. At the low current values required to weld these light sheets, the reversal periods of low current flow exceed the twenty micro-second maintenance period and the arc would not be continuous, without the introduction of peak currents every five micro-seconds or four peaks in the period normally required for the loss of ionization. This results in an extremely stable arc despite the low currents of 50 to 80 amperes.

A.c. is used in preference to d.c. to avoid the troubles associated with arc blow due to magnetic effects which are always present with d.c. and never with a.c.

The diagrams in Fig. 6 show graphically how this high frequency stabilization does its work. The upper diagram represents an a.c. sine wave for the low currents desired, showing the large proportion of time during which the current value is too low for arc maintenance. The central diagram indicates the high frequency used to maintain ionization through this period, while the lower diagrams show why the higher currents are stable without high frequency though the lower ones are not.

The light sheet field for arc welding is largely a production proposition in which jigs are used, as for example in the food compartments previously referred to. The inside block has replaceable corners by which the shape of the deposited metal is controlled so that any desired inside contour may be obtained. (See Fig. 7.)

### Resistance Welding

In turning to the general subject of resistance welding, particularly the spot- and seam-welding divisions, it may be noted that this important field has had too little attention as compared with the more spectacular arc-welding process.

The year 1936 marks the fiftieth anniversary of Elihu Thomson's discovery of resistance welding, a process without which modern low cost automobiles, refrigerators, and household appliances would scarcely be possible. Some idea of its importance is indicated by the fact that there are 3,415 welds in a popular four-door sedan, of which 3,154 are spot welds and 44 are other forms of resistance welding. A 6½-cubic foot refrigerator uses 1,509 welds, of which 1,338 are spot welds and 32 of other resistance types. It is interesting to note at the same time that since 1932 each year has seen a greater tonnage of steel ingots go into sheets than into any other form of steel and that in 1935 sheets accounted for over 42 per cent of the steel produced in the United States.

In resistance welding the parts to be welded are heated by passing a heavy single phase low voltage current through the material and pressing the parts together. The electrical resistance at the point where the two or more pieces are in contact results in rapid heating, the pressure forcing

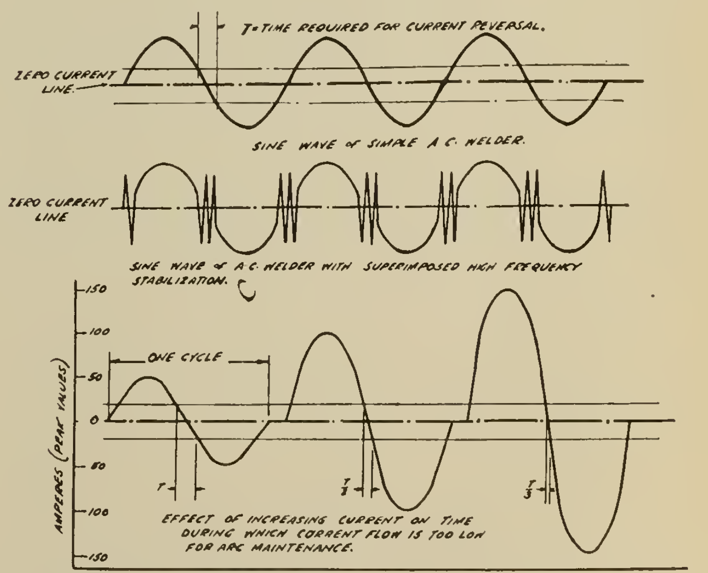


**Fig. 6—Sine Waves for Simple and High Frequency Types of a.c. Welders.**

them together when fusion temperature is reached. The weld may thus be considered as plastic and is distinct from the so-called fusion processes of oxy-acetylene and arc welding which depend for union on the flowing together of liquid metal without the assistance of external pressure.

Alternating current only is used due to the ease with which commercial currents may be transformed into the low voltage-high amperage required; two to eight volts and 300,000 to 800,000 amperes per square inch of contact surface are generally used. Current strength is controlled by means of taps in the primary circuit of the welding transformer. Secondary windings are usually single turn copper forgings or castings, parallel connected by leaf type conductors to the welding arms. The control apparatus is always in the primary circuit and its design requires special attention.

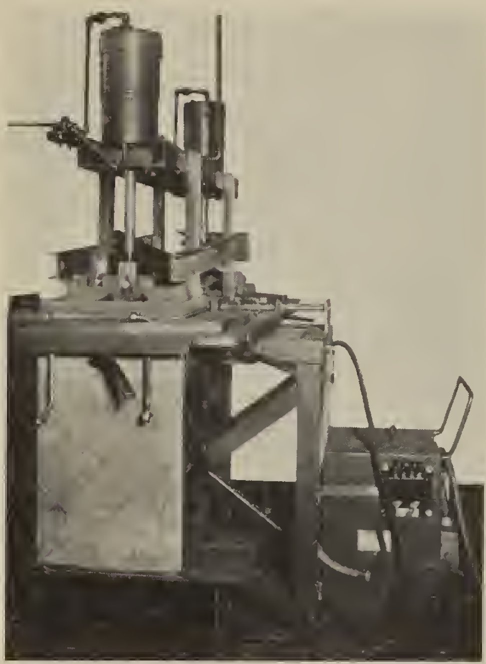

**Fig. 7—Welding Fixture and Equipment for Arc Welding Food Compartments. Welding Speeds 22 to 23 inches per minute.**

Resistance welding is roughly divided into five branches, spot welding, projection welding, seam welding, butt and flash welding. In the first three overlapping flat stock is welded, while in the two latter bar stock is welded end to end, or sheet stock edge to edge.

Spot welding is the best known and most used type and consists of welding a spot through two or more pieces of lapped material, the size and shape of the spot being controlled by the dimensions of the welding tip faces. Its function in joining metals is similar to that of a rivet which it replaces.

The process may be used with any form of ferrous metal sheet or bar and is almost equally successful in the non-ferrous field with mild steel, stainless steel, galvanized iron, aluminum, brass, and the newer copper-silicon manganese alloys welded both to themselves and in various combinations.

Three types of machines are in common use, namely, manual, in which the welding points are brought into contact by man power aided by foot or hand levers; mechanical, acting after the manner of a punch press but with a cam instead of a crank in order to hold the points together for an appreciable period; and pneumatic, in which an air cylinder provides for point motion and pressure.

The important factors in the production of uniform high grade spot welds are current strength, time of current application, pressure of welding points, and the size of the spot to be welded, while the basic principle is that the weld shall be made with as little thermal disturbance of the metal as possible. This involves the shortening of the current period to a minimum, which can only be done by using very high currents, which in turn require extremely accurate time control. It is in the control of welding times that important advances have recently been made, making possible the production of millions of welds without a half cycle variation and resulting in such uniformity and quality as was undreamt of a short time ago.

Before considering the important feature of time control, however, attention should be drawn to other related factors, including the size of the welding points. It is obvious that tip area should be held constant, since any increase or decrease from the predetermined size results in a corresponding but reverse change in unit pressure and current concentration. In the author's work $\frac{9}{32}$ diameter is found best and tips under $\frac{1}{4}$-inch or over $\frac{5}{16}$-inch diameter are not used except on jobs where there is a difference in thickness between the two pieces to be welded. In such cases the tip size used on the lighter stock is in inverse ratio to stock thickness. For example, in welding $\frac{3}{16}$-inch stock to 20 gauge, this is done by a one-inch tip against the light sheet and a $\frac{1}{4}$-inch against the $\frac{3}{16}$-inch plate.

Another exception to the rule of similar tip sizes is when it is undesirable to have indications of a weld in the outside face of one or other of the welded sheets. In this case a copper bar $\frac{1}{4}$ inch by 2 inches of any desired length is placed between the tip and the face which it is not wished to mark.

Uniformity of pressure of the welding points against the material is also important, and modern machines are built with it in mind. Pressures used must be high enough to hold the parts firmly together and low enough to prevent excessive reduction in thickness. Lower pressures will also require less current for a given job than will higher pressures but the higher range gives greater uniformity by reducing the variation in joint resistance due to irregular surface conditions.

It has been found on 20-gauge cold rolled cleaned steel sheets that 200 to 400 pounds total pressure on a $\frac{9}{32}$-inch diameter tip is a good range with an optimum condition at 325 pounds. Higher pressures are required for the high strength non-ferrous alloys and somewhat lower on the softer materials.

The current should always be the maximum that the job will carry consistent with effective control, i.e. if the current can be controlled to a fraction of a cycle, then one cycle welds are practical provided capacity is available to do it in that time.

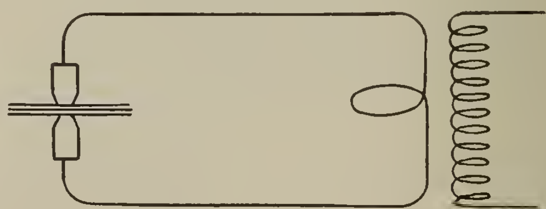


**Fig. 8—Resistance Welding Circuits and Currents.**

This in turn brings up the question of machine sizes. Probably 90 per cent of all machines in use today are too small for the work they are asked to do. This compels the use of excessive times with the resultant defects due to thermal disturbance, large reductions in total joint thickness, accompanied by poor appearance. Another factor worthy of consideration is the length of the welding arms.

It is customary for buyers with an eye on future work to feel that they should get a unit with plenty of throat depth to take care of whatever may come along. This attitude is permissible if a decision on the capacity of the outfit is made with the knowledge that for every 6 inches added to the arm length 25 per cent should be added to the rating. Excessive as this may seem it is in entire accord with electrical laws governing resistance welding conditions. Experience supports this. For example, in one case a particular job on a 60-kv.a. machine was done with 12-inch arms that could not be done on a 100-kv.a. unit of the same make and type with 30-inch arms. A large amount of induction is created by these high amperage low voltage currents. Thus when trying to measure the secondary currents in a large spot welder, it was found that an ammeter 20 feet from the machine and out of circuit registered appreciable currents as a result of the inductive forces released.

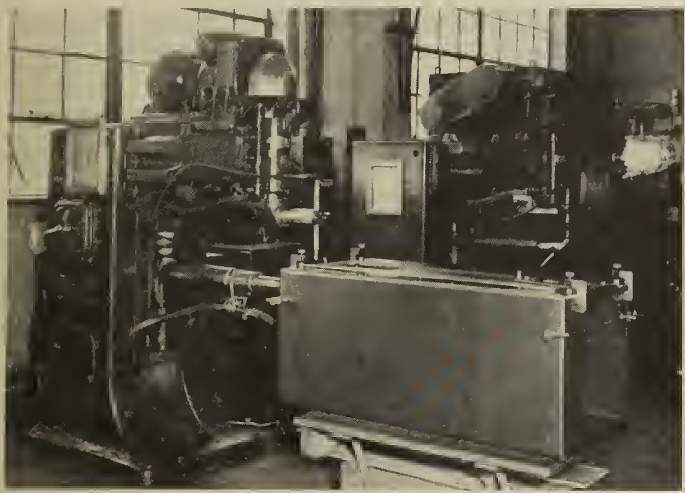

**Fig. 9—Modern Spot Welders used in the Production of All-Steel Refrigerator Cabinets.**

Another simple proof is to hold a steel object close to the arms of a working machine and feel the pull of the inductance, while a noticeable heat is induced in a file held near the arms of a rapid spotting machine for a few moments.

As regards time control, a number of methods are found to be in use. The first method, now entirely obsolete, was by means of a magnetic contactor operated by push button control, in which the time of current flow was determined by the length of time the operator held in the push button. The time of current application was a matter of the operators' judgment on every spot. This resulted in great time-variation, measurements with a cycle counter on an expert workman showing an extreme short time of 3 cycles and a long of 24 on the same job within one hour. His ordinary variation was from 8 to 18 cycles or from one-eighth to one-third of a second. This is remarkably good operating judgment but involved 225 per cent ordinary variation and an extreme difference of 800 per cent in the amount of current passing through the work.

Table II

Time Variations Obtained by Different Methods of Control

| Method | Variations in Cycles |
|---|---|
| Manual | ±10 |
| Mechanical | ± 2 |
| Electronic contactor | ± 1 |
| Ignitron | ± 0 |

In mechanically operated machines, time control is commonly obtained by means of a cam-operated switch to actuate the contactor. The method results in a variation of approximately four cycles from the setting desired, so that times as high as ten cycles may be 20 per cent over or under any spot. Still closer control on any type of machine may be obtained by the use of electronic contactor timers to control the magnetic contactor. With this system of radio-type tube control the closing of the initiating switch by a push button or cam starts a complete cycle of timer operation which closes the main switch and holds it in for the predetermined time, at the close of which it is opened and the entire timing mechanism is in position for the next weld.

This type of control will reduce variation to a maximum of two cycles, one under and over the desired value, and will operate down to about six cycles of 60-cycle current or one tenth second. Thus it will do reasonably good work on low carbon steels but is scarcely practical for work on aluminum, stainless steels, very thin materials requiring short accurate timings, or any high resistance or short plastic range metal.

The use of a magnetic contactor to interrupt the primary current, with inevitable arcing and burning of the contact faces, results in high maintenance costs, loss of production, and—what is of greater importance—a variation in the amount of current passed due to the surface resistance of dirty contact faces, and they are dirty after two or three hundred operations that on a high speed machine are made in something under five minutes.

For more uniform work of higher quality than is possible with a magnetic contactor, a timer is required in which the primary current for the welding transformer passes through and is controlled by electronic tubes. One such timer is known as "Ignitron" control which brings time as a factor in resistance welding under precise control, using no moving current carrying parts. Power current is conducted and interrupted by two Ignitron tubes which function as controlled current rectifiers. The tubes are connected in parallel reverse relation, the combination serving to pass alternating current, and are connected directly between the power source and the welding machine. They are of the mercury pool cathode type. The control feature consists of an Ignitron electrode dipping into the mercury pool. A small ignition current flowing into the pool through this electrode "fires" or causes ionization of the tube for each desired loop of welding current. Once a half cycle of power is initiated in either of the Ignitron tubes it will continue to the end of the loop, at which time the arc is automatically extinguished. Contactors or relays are not depended on, either to interrupt the power current or to control the duration of the weld.

Timing is controlled by electronic circuits whose purpose is to measure out a predetermined number of cycles of welding current during closure of a control switch in the electronic circuit. This switch may be either manual or machine operated. In spot welding, one spot is obtained for each closure of the switch, while in seam welding a succession of spots is obtained as long as the controlling switch is closed. The timing and ignition circuits co-acting with the Ignitron tubes may be likened somewhat to the ignition system of the average automobile. The Ignitron tubes correspond to the cylinders, the ignition electrodes to the spark plugs, and the grid controlled tubes in the Ignitron circuit to the spark coil, while the electronic timing circuit corresponds to the distributor.

The outstanding advantages of this type of timer are extreme precision (even on one cycle welding), low maintenance and adaptability to modern production schedules.

### Testing Spot Welds

It is good policy to provide every spot welder with test material which may be strips, half an inch or more in width and three to four inches long, of the material being used. It can frequently be obtained from trimming die scrap. Regular tests should be made at intervals of not more than fifteen minutes, plus every time the tips are dressed or other adjustments are made. These tests only involve making of two or three spots on a pair of pieces, slipping one end into a vise or holding fixture and tearing them apart with a slotted tee handled bar. A good weld will invariably tear a hole in the parent stock, but some

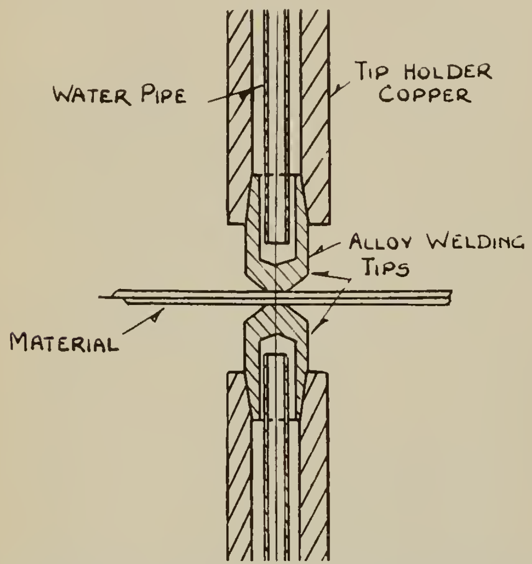


**Fig. 10—Cross-Section of Spot Welder Tips, showing Method of Cooling.**

care is required in interpreting this result since an overwelded spot can be easily torn out, though overwelding tells its own story. Thus if the test spots have good appearance, are not excessively dented and break the parent stock rather than pull apart the weld can be safely used in any well designed product. In making test welds the loaded fixture should be between the welding arms to insure that induction losses during the tests will correspond with those in service.

Machines should be kept clean, especially all contacting surfaces through which current passes, since extremely thin films of grease or oxide will seriously restrict the flow of current. A free flow of cooling water is essential and this must get right into the welding points. Figure 10 illustrates a cross section of a pair of spot welder tips showing the method of cooling. The cooling water pipe should end inside the welding tip which may be of copper-cadmium, copper-chromium or copper-tungsten alloys. Stock should always be clean, and though it is possible to weld low carbon steels without removing mill scale, this introduces serious irregularities and such welds should never be used to carry an appreciable load. Non-ferrous metals, excepting aluminum, should be cleaned within three to four hours of welding to ensure uniform results. Aluminum is the exception that does better with the slight film of oxide on it that it always picks up when exposed. Oil or grease is fatal to good welds with any material.

Projection welding is simply a method of multiple spot welding in which one piece of the material is embossed into a raised point wherever a weld is desired. Dies are used in very powerful machines to weld a number of these points simultaneously.

### Seam Welding

Seam welding consists of spot welding with the welds so close that each one overlaps its neighbour. For gas- or oil-tight joints, ten to fourteen spots are made per inch of seam. Circular revolving discs are used instead of electrode points and Ignitron or other synchronized control is needed since the welding currents must be applied and cut off for each spot with welding speeds as high as twenty spots per second, resulting in up to 10 feet of seam per minute. Attempts have been made to seamweld with the current uninterrupted, but a building up of the heat results either in failure to weld the first few inches or in a burning of the joint if the applied currents are heavy enough to weld from the start. The interrupted method has eliminated this difficulty, producing first class uniform welds along the entire seam.

The synchronous timer which delivers timing impulses to the Ignitron control tubes consists of a synchronous motor, speed reducer, aluminum timing disc and magnetic pick up. The disc has a series of holes drilled around the edge, each hole corresponding to one-half cycle of the power supply. For each half cycle of current conduction desired, a steel pin is inserted in the disc. Thus to put in six pins adjacent to each other would be to pass three cycles of current, to leave out the next six would interrupt three cycles and to continue with six in and six out would be to use a three cycle on and three cycle off welding time. Similarly to put in two pins and leave five out around the disc would be to set it for one cycle on with two and one-half cycles off. Any combination of on and off times is instantly available.

Spot welding may be done on such a seam welder by increasing the off period as three on and twenty-seven off, producing two spots per second, or two on and fifty-eight off for one spot per second or any other desired combination that will work out in the 120 holes in the disc. The distance such spots are apart is controlled by the speed of the disc and will be uniform.

By means of the spot or seam forms of resistance welding all of the following metals may be welded to themselves and to every other one in this group, though combinations of copper to others present the most difficult problems,

Ingot iron
Mild steel
Stainless steel (18–8)
Nickel
Nichrome
Monel metal
Nickel silver
Brass
Bronze
Copper-manganese-silicon alloys
Copper

Aluminum is weldable to itself and to one or two other metals despite the problems due to the short plastic range it possesses.

Any of the plated forms of low carbon steel are readily welded though it is difficult to prevent damage to the coating. Cadmium and zinc are picked up by the electrodes, involving frequent redressing of the wheels or tips.

Aluminum-bronze with up to 10 per cent aluminum and the new copper-beryllium alloys have good resistance welding properties.

So many practical welding combinations have now been produced that a nationally known engineer stated recently that he would like to discover a combination of two metals that could not be welded together under any circumstances, and that such a combination would be extremely valuable.

# Some Debatable Points in the Design of Hydraulic Regulating Gates

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Normally the design of a gate is considerably simplified from the fact that the main load from the water pressure is static and definitely known. However, there are three other fairly common loads which are not so easy to make accurate allowance for. They are the loads from water flowing over the top of the gate, water flowing underneath the gate, and ice loads.

### Water Flowing Over the Top

Sluice gate specifications often call for a gate designed for a normal high water level at the top of the gate, and capable of withstanding perhaps four feet overflow for an emergency case. The top girder in a large gate may be five feet in depth and one foot below the top of the skin plate. See Fig. 1. At "*a*" there is probably very little pressure, or possibly even a vacuum due to the water springing clear from the top of the plate, at "*b*" there may be almost five feet due to some impact, and, at "*c*" perhaps two feet. The distribution and the loading will vary with the depth of the overflow, the depth of the girder and the height of the plate above the girder. In the author's opinion a conservative treatment is to figure on one-half of the overflow distributed over the whole area of the top girder and to provide adequate web stiffeners, and supports for the downstream flange.

### Water Flowing Underneath the Gate

In head gates the skin plate is usually placed on the downstream side to simplify the sealing of the top edge of the gate along the lintel. In gates of this type operating under high heads the bottom girder has to be placed fairly close to the bottom of the gate to take the load from the skin plate. These gates are sometimes called on to close

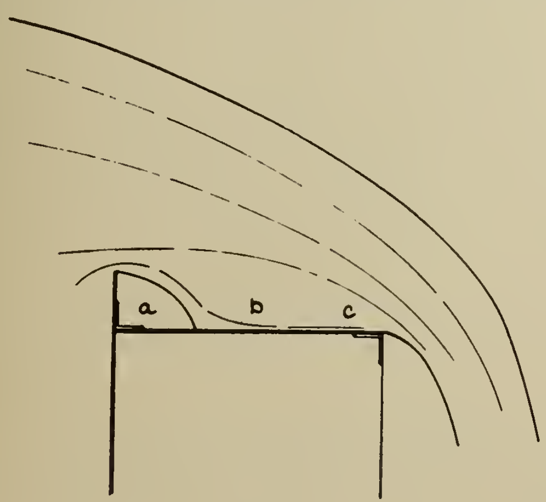


Fig. 1.

openings under free discharge conditions. See Fig. 2. "*A*" shows a flat bottomed gate. As this gate is lowered into the fast moving water, the water springs clear at "*m*." As the gate approaches the sill the water tends to curl up towards "*n*" till a point is reached where it touches the gate at "*n*" and cuts off the air pressure on the bottom of the gate causing a sudden increase in the load on the lowering mechanism.

In order to reduce this vacuum effect it is customary to put a taper bottom on the gate as at "*B*." There will still be a vacuum formed at "*m*," but the area affected will be much smaller and the application will be gradual. The longer the taper and the longer the straight lip the better, but both are limited by strength considerations. Even if the vacuum is eliminated entirely there always will be a big loss in upward water pressure.

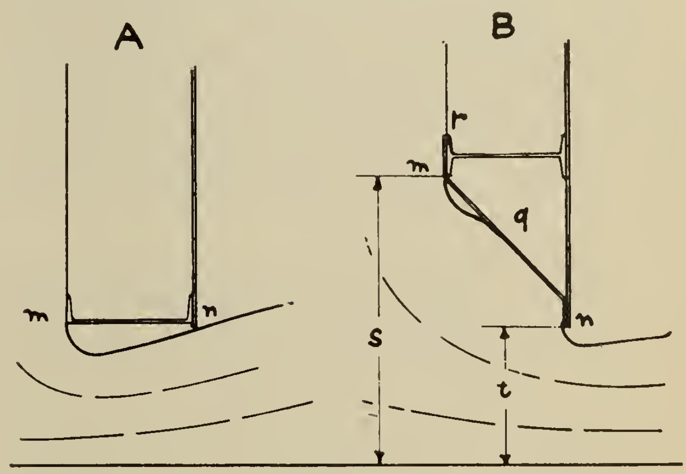


Fig. 2.

Assuming there is no static head left in the water as it leaves the gate at "*n*," then the static head or upward pressure at "*m*" will be the difference in velocity heads at "*n*" and "*m*" and the average pressure on the bottom of the gate will be about one half of this. The velocities at "*n*" and "*m*" will be approximately proportional to the dimensions "*s*" and "*t*." With the gate open a number of feet the difference between "*s*" and "*t*" becomes small giving a small difference in velocity and a small upward pressure. The downward pressure inside the gate at "*q*" is almost that due to the vertical head, being a little less due to the "draw off" from the slight downward velocity at "*r*."

To be safe this downward load on a gate should be figured as the full head at the bottom of the gate by the horizontal area, as while there may be a slight upward balancing pressure, there may also be some vacuum effect. To illustrate the size of this load a 15-foot wide gate with a 24-inch girder under 60-foot head will have a load

$$= 15 \times 60 \times 62.5 = 112{,}000 \text{ pounds or 56 tons.}$$

In lowering a gate this load is partly balanced by the friction of the gate. In raising a head gate in a power house it is good practice to open it a few inches and fill the penstock, then lift it right up in still water. When it is open only a few inches the difference between "*s*" and "*t*" is great so there is considerable upward pressure. But if the gate has to be designed to open up a free discharge this load should be included in figuring the lifting mechanism. This shows the importance in gate design of obtaining full details of operating conditions.

A number of large holes in the bottom plate are helpful, by reducing the area and by causing turbulence and hence increased pressure on the bottom side.

### Ice Loads

Some experimenters have given the possible ice pressure on a gate as 10,000 pounds per linear foot along the water line. As the water line may often vary five feet allowing for this load makes a very heavy top section on the gate. Numerous gates in Canada have been built without any allowance being made and have apparently not sustained any damage through being frozen in all winter. The explanation of this is probably that the gate deflects under the load and allows the ice to expand losing its pressure. Damage from ice during the spring break-up is a different matter. This is caused by large pieces of ice knocking into a partly opened gate before passing through underneath. As these pieces of ice may be very large—for example, 50 feet square by 2 feet thick weighs 150 tons—it is economically impossible to make a gate strong enough to withstand the shock without damage. In the author's experience the ice usually pushes in the skin plate and stiffeners, and the damage done is fairly easily and cheaply repaired with a cutting torch and a welding outfit. If the stiffeners are made stronger there is danger of serious strains in the main girders. The cure seems to be a case of prevention. The gates should not be left partly open with ice in the river. Possibly a balanced gate for quick operation would make the problem easier, as it would permit timing the opening to avoid the larger pieces of ice.

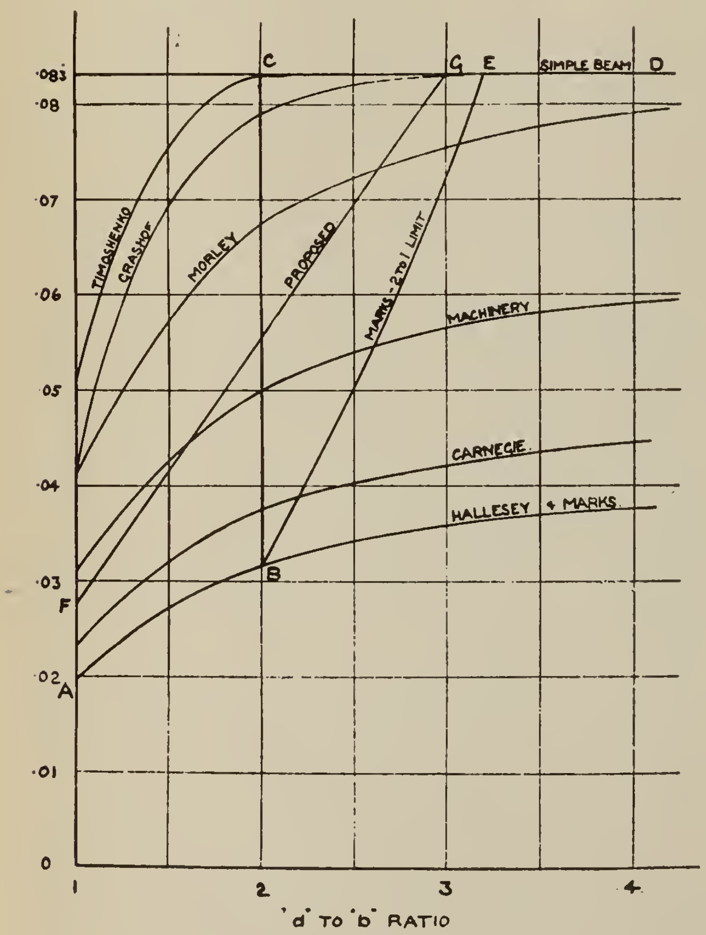


Fig. 3.

### Skin Plates

The usual practice in Canada when building a gate is to have the skin plate stiffeners framed in between the main girders. The skin plate is riveted to the main girders and to the stiffeners. As the main girders are usually very rigid in comparison with the plate, and as the plate is continuous over a number of stiffeners, it seems reasonable to treat the plate at a panel as being supported on four sides with fixed edges. Various authorities give widely different formula for this condition.

Hallesey, and Marks' Handbook both give

$$f = .24 \frac{b^2d^2}{b^2 + d^2} \times \frac{W}{t^2} \text{ or } M = .04 \frac{d^2}{b^2 + d^2} \times b^2w$$

where $f$ = Stress per square inch
$b$ = Breadth of panel
$d$ = Depth of panel
$w$ = Load per square inch
$t$ = Thickness in inches
$M$ = Bending moment

Carnegie's Pocket Companion, Machinery's Handbook and Morley's Strength of Materials, all give the same formula but use 9/32, .375, and .5 for factors instead of .24.

In the Mechanical World Pocket Book the Grashof formula is given as

$$M = \frac{1}{12} \frac{d^4}{b^4 + d^4} b^2w$$

Applied Elasticity by Timoshenko and Lessells gives

$$M = K\, b^2w$$

with a table of values of $K$ for various ratios of $d$ to $b$.

Figure 3 shows the values of $K$ for the various formulae plotted on a basis of $d$ to $b$ ratio. The straight line along the top represents $M = 1/12\, b^2w$ — treating the plate as a simple beam — and it would be expected that all the curves would tend to be tangential to this line when $d/b = \infty$, but this is not the case. The explanation probably is that the stress given in the first formula is the average along the diagonal, though Morley is the only writer to make this point clear. For an infinitely long rectangle the maximum stress along the diagonal will be considerably greater than the average.

It is common practice when using any of the more optimistic formulae to limit their use to a $d$ to $b$ ratio of 2 though none of the authorities quoted give any limit. The curve then becomes $ABCD$. which apart from looking all wrong has another defect. For example with $b = 1$ and $d = 3$.

$$M = .083\, b^2w \text{ or } .083\, w.$$

Now if $b$ is increased to 1.5 the $d$ to $b$ ratio is within the limit

$$\text{and } M = .04 \frac{d^2}{b^2+d^2} \times b^2w = .04 \frac{9}{2.25+9} \times 2.25\, w = .072\, w$$

That is to say that by increasing the spacing of the stiffeners by 50 per cent the stress is actually reduced. This defect can be overcome by putting $c = 1/2\, d$ in place of $b$ in the formula,

$$\text{and} \qquad M = .04 \frac{c^2 \times 4\, c^2}{c^2 + 4\, c^2} w$$

$$= .032\, c^2w$$

and the curve now becomes $ABED$ which looks a little better.

However, it is obvious that the "optimistic" formulae are not rational and the first reaction would be that it is not sound practice to use them. But a great many gates in Canada have been designed to Hallesey's formula with a ratio limit of 2 and a figured stress of 18,000 pounds per square inch and after many years of service have given no indication of overload in the plate. It is sometimes argued that if a skin plate fails when acting as a beam it will deflect enough to take the load as a catenary, but a few figures soon show that before this effect takes place the plate would be stressed far above the elastic limit and would thus show a permanent set.

On looking at the various formulae on the graph, and bearing in mind the satisfactory performance of the most optimistic one in actual service, the reasonable conclusion seems to be to devise some simple formula which will give a curve lying between the extremes.

The straight line *FG* is obtained by using

$$M = 1/36\ bdw$$

or

$$f = \frac{bdw}{6t^2}$$

up to the ratio $d$ to $b = 3$.

To be rational it should be a curve but to obtain this would detract considerably from the simplicity of the formula and would also seem to claim greater accuracy for it than it possesses.

### Side Guide Rollers

The proper function of a side guide roller is to centre the gate between the side guides before it has to take the water pressure. If the gate rollers are not dead in line with the side guides the gate will tend to roll to one side causing it to bear hard against the side guide roller concerned. If the gate is almost closed when this happens the roller will be called on to skid the whole gate under the full water pressure. In a large gate this pressure may be as high as 500 tons and with a coefficient of sliding friction of .1 this means a load of 50 tons on the roller.

To assist the lining up in the field side guide rollers are usually made adjustable. This adjustment often consists of a screw behind the roller bracket. The author has seen many gates with this screw or bracket bent up and the roller pushed in. The probable explanation is that each time the gate goes down the roller is pushed in perhaps only a few thousandths, but as the load is so great something has to yield and the result is a permanent set.

The roller and supports should be made strong enough to take the load, or probably it would be better to use a simple curved guide plate of spring steel which would centre the gate before lowering, and which would always spring back to the same position even if it were deflected a little each time the gate went down.

The views expressed in this paper are the result of the author's experience while employed on gate design by Glenfield and Kennedy Ltd., hydraulic engineers, Kilmarnock, Scotland, for two years and with the Dominion Bridge Company Ltd., for the last seven. Naturally it is through the author's association with these two firms that he has any ideas about gates at all, and he is deeply indebted to them for the experience gained while in their employment. However, it should be understood that the views expressed are not necessarily those held by either of the two firms mentioned.

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# The Royal Engineers in British Columbia—1858-1863

*His Honour Judge F. W. Howay, LL.D., F.R.S.C.*

**An Address delivered at the Western Professional Meeting of The Engineering Institute of Canada, July 11th, 1934.**

(*Slightly Abridged*)

In the spring of 1858, the world became aware of the existence of gold in the bars of the Fraser River. The mainland of British Columbia was, at that time, merely a vast fur preserve of the Hudson's Bay Company. Its only white inhabitants were less than a score of men scattered amongst the eight or ten widely-separated trading posts of the company. It had no roads, or other civilized means of communication; only the most rudimentary trails, and very few of them. In fact, save for these few forts or trading posts, and save for a little agriculture, that went on around them, it was in a state of nature. There was no government, organized or otherwise. The place was just a "wild, waste land" as Tennyson calls it "where no man comes or hath come, since the making of the world." And it hadn't even a name.

That was the situation when, in April, May, June and July of 1858 a horde of adventurers, seeking the yellow root of all evil, set out from San Francisco. Twenty-five or even thirty thousand people left California, all headed for the Fraser River. They knew nothing of the land or of the climate; all they knew was there was gold, and they were going for it.

Now, at that time, there was a Colony of Vancouver Island, with a Governor, James Douglas, but on the mainland the territory was unorganized. Thus when these people began to arrive from California, the only person who could act at all was Governor Douglas. As Governor of Vancouver Island he had nothing to do with the mainland; but, inasmuch as he was the nearest Crown authority, he naturally wrote to the Home authorities, advising them of what was going on, and was instructed by Sir Edward Bulwer-Lytton, who was then Secretary of State for the Colonies, to act as though he were Governor on the mainland—and do what was, in his judgment, necessary.

As these people came swarming in, Governor Douglas remembered that there were many of them with unsavoury reputations; and California, twice in her history as a gold mining state, had been compelled to form Vigilance Committees to overthrow the weak Courts, and by means of illegal courts, put down illegality! As Governor Douglas was determined to prevent any such condition under the British flag as had occurred in California, he wrote to Sir Edward Bulwer-Lytton, asking him to send a detachment of soldiers, that they might keep order in the country. At that time communication was slow, for the mail had to go by way of Panama, and Governor Douglas' letter, which is dated in July 1858, crossed a letter from Sir Edward Bulwer-Lytton. Governor Douglas had written for soldiers, and Sir Edward Bulwer-Lytton had written to say that he was going to send some. For this purpose Sir Edward had selected the Royal Engineers; and in his letter to Governor Douglas, he indicated just why he had chosen that distinguished corps. In describing the quality of the men he was sending out, he said "The superior discipline and intelligence of this force, which afford ground for expecting that they will be far less likely than ordinary soldiers of the line, to yield to the temptation to desertion offered by the goldfields, and their capacity at once to provide for themselves in a country without habitation, appear to me to render them especially suited for this duty; whilst by their services as pioneers in the work of civilization, in opening up the resources of the country, by the construction of roads and bridges, in laying the foundation of a future city or seaport, and in carrying out the numerous engineering works which in the earlier stages of colonization are so essential to the progress and welfare of the community, they will probably not only be preserved from the idleness which might corrupt the discipline of ordinary soldiers, but establish themselves in the popular goodwill of the emigrants by the civil benefits it will be in the regular nature of their occupation to bestow."

There are his reasons for choosing the Royal Engineers.

Volunteers were called for, and from them 150 non-commissioned officers and men were chosen. That body, under the command of Colonel R. C. Moody, came out in three sections. The first detachment, numbering twenty under Captain Parsons, were mostly surveyors. The second detachment of twelve under Captain Grant, were mostly carpenters. The third section, comprising the main body of 118 non-commissioned officers and men, were accompanied by the women and children. Captain Parsons' and Captain Grant's contingents, totalling thirty-two men, came by way of the Isthmus of Panama, not all together, but they both arrived here about November 1858. Sir

**Present Cariboo Highway, Fraser River Section.**

Edward Bulwer-Lytton is remembered as a novelist and a dramatic author of outstanding ability, but he was also an orator. Moreover, his correspondence, in laying the foundations of British Columbia, shows that he was a statesman—a man of broad outlook and vision.

Sir Edward went down to the ship "La Plata" to say good-by to the Engineers—the first twenty sailing with Captain Parsons; and his address to them on that occasion contains passages which may even stand side by side with Lincoln's celebrated address at Gettysburg. In that address Sir Edward said: "Soldiers, I have come to say to you a few kind words of parting. You are going to a distant country, not, I trust to fight against men, but to conquer nature; not to besiege cities, but to create them; not to overthrow kingdoms, but to assist in establishing new communications under the sceptre of your own Queen. For these noble objects, you soldiers of the Royal Engineers have been especially selected from the ranks of Her Majesty's Armies. Wherever you go, you carry with you, not only English valour and English loyalty, but English intelligence and English skill. Whenever a difficulty is to be encountered which requires not only courage and discipline, but education and science, sappers and miners, the Sovereign of England turns with confidence to you. If this were a service of danger and bloodshed, I know that on every field and against all odds, the honour of the English arms would be safe from a stain in your hands, but in that distant region to which you depart, I hope that our national flag will wave in peaceful triumph on many a Royal birthday from walls and church towers which you will have assisted to raise from the wilderness, and will leave to remote generations as the bloodless trophies of your renown. Soldiers, you will be exposed to temptation, you go where gold is discovered, where avarice influences all the passions, but I know that the voice of duty and the love of honour will keep you true to your officers and worthy of the trust that your Sovereign places in Her Royal Engineers. For my part, as one of the Queen's ministers, I promise that all which can conduce to your comfort and fairly reward your labours shall be thoughtfully considered. You have heard from my distinguished friend, your commanding officer,* that every man amongst you who shall have served six years in British Columbia and received at the end of that time a certificate of good conduct, will be entitled if he desires to become a resident of the Colony, to thirty acres of land,† aye, and of fertile land, in that soil which you will have assisted to bring into settlement and cultivation. In the strange and wild district to which you are bound, you will meet men of all countries, of all characters and kinds. You will aid in preserving peace and order, not by your numbers, not by mere force, but by the respect which is due to the arms of England, and the spectacle of your own discipline and good conduct. You will carefully refrain from quarrel and brawl. You will scorn, I am sure, the vice which degrades God's rational creatures to the level of the brute—I mean the vice of intoxication. I am told that is the vice which most tempts common soldiers. I hope not—but I am sure it is the vice which least tempts thoughtful, intelligent, successful men. You are not common soldiers, you are to be the pioneers of civilization. Nothing more counteracts the taste for drink than the taste for instruction, and Colonel Moody will endeavour to form for your amusement and profit in hours of leisure, a suitable collection of books. I beg to offer my contribution to that object, and I offer it not as a public minister, out of public moneys, but in my private capacity as a lover of literature, myself, and your friend and well-wisher.

"Farewell, Heaven speed and prosper you. The enterprise before you is indeed glorious. Ages hence, industry and commerce will crowd the roads that you will have made; travellers from all nations will halt on the bridges that you will have first flung over solitary rivers, and gaze on gardens and cornfields that you will have first carved from the wilderness; Christian races will dwell in the cities of which you will map the sites and lay the foundations. You go, not as enemies, but as the benefactors of the land you visit, and children yet unborn will, I believe, bless the hour when Queen Victoria sent forth her sappers and miners to found a second England on the shores of the Pacific."

That was Sir Edward Bulwer-Lytton's address; worthy of the occasion, and worthy of being remembered by the people of British Columbia.

The thirty-two men of the Royal Engineers who came by the Isthmus of Panama, arrived in time to take part in the formal launching of the Colony of British Columbia; for in the interval, an Act had been passed creating the Colony of British Columbia, to come into force on its being promulgated in the country; and that promulgation was made at Langley on the 19th of November, 1858. Governor Douglas was then sworn in as the Governor of the Colony of British Columbia, so that there were two separate colonies, Vancouver Island and British Columbia, with one Governor.

The two detachments of Royal Engineers at once began the work of getting ready the buildings for the larger body—the contingent that was coming round the Horn in the "Thames City." They built for a while at Derby; and then their work was interrupted by a "war"—one of the most bloodless wars on record, a war without a shot being fired; the story is complicated, and as it goes along it reminds one of the "House that Jack Built."

*Colonel Moody.

†Later increased to 150 acres.

On Christmas Day of 1858, there were at Hill's Bar, one and a half miles from Yale, two miners who determined to celebrate. Their idea of celebration was to go to Yale and get drunk. Up to Yale they went, and drunk they got. As they were strolling—or rolling—in that condition, on the one street of Yale, they happened to see a negro sitting in the door of his barber's shop. They were in that sort of humour that when they saw this negro they got the idea that the negro ought not to breathe the same atmosphere as theirs; and to impress that upon the negro they beat him up and then strolled back to Hill's Bar to sober up. The negro went to the Magistrate at Yale—a very pompous man—complaining of the assault made upon him, and making charges against the two miners. At once the magistrate issued a warrant for the arrest of these two men for assaulting the negro; and, to make sure he would have the negro when he wanted him at the trial, he locked him up—put him in jail—although he had not got the men who were supposed to have committed the assault. Then he sent his constable to Hill's Bar to get the two miners. But Hill's Bar had a little sailor magistrate, by the name of Perrier, and he did not see why these men who had beaten the negro at Yale, should be tried at Yale. He thought he should try them at Hill's Bar, and when the Yale constable came with the warrant to get the two men the little sailor magistrate regarded it as contempt of his court, to take them to be tried at Yale. He refused to let the two men go, and ordered his own constable to lock them up in the jail at Hill's Bar. So the men who did the mischief were locked up at Hill's Bar, and the poor negro to whom it was done, was locked up at Yale. The magistrate, Perrier, sent his constable up to Yale to ask the magistrate there, "Captain" Whannell, to allow the negro to go to Hill's Bar to give evidence against the men. But when the constable got to Yale and asked for the negro, the Yale Magistrate became very, very angry. He thought it was contempt of his court, that the magistrate from Hill's Bar should send up to get the negro. He refused to let him go, and, what is more, he took the constable from Hill's Bar and locked him up in Yale for coming up to try to get the negro!

When this news reached Hill's Bar, there was great commotion. At that time, there was a man named Ned McGowan at Hill's Bar—a notorious renegade. He was formerly a judge in California, but he had gone downhill, and in the end, being charged as an accessory to a celebrated


Map of Southern British Columbia.

murder in California, he was wanted by the Vigilance Committee. His life was not worth a minute's purchase. One of the Agents of the Vigilance Committee took a shot at him, but unfortunately he was a poor marksman, and the bullet went through the lapel of McGowan's coat; and it caused us a lot of trouble. He came to the magistrate at Hill's Bar, and said "If you will give the authority to me and my friends, we will go up to Yale and release that nigger and bring him down here, and we will release your constable who is locked up there for contempt of court; and, what is more, we will arrest the Yale magistrate and the Yale constable for contempt of your court, and bring them down here." And accordingly it was done. McGowan and his friend went to Yale, and they stamped into Whannell's court room, took possession of the magistrate and his constable—they unlocked the doors of the jail and got the negro, and got the Hill's Bar constable, and the procession came down to Hill's Bar. When they got there, the little magistrate at Hill's Bar sat very solemnly in the matter, and fined Farrell and Burns (the miners who had beaten the negro) seventy-five dollars for committing the assault. Then he had the Yale constable before him for contempt of court in arresting the Hill's Bar constable and locking him up. But the Yale constable said "I did it under order of the Yale magistrate" and the Hill's Bar magistrate said "Well, that is all right; you carried out your instructions." Then he brought his fellow-magistrate before him—tried him for contempt of court for locking up his constable and fined him twenty-five dollars. The magistrate of Yale was as angry as he could be; sent a letter to Captain Grant who was in charge of the Royal Engineers at Langley, telling him that this renegade of renegades had been prison breaking at Yale and was in a deep-rooted conspiracy to overthrow British authority, and hand the country over to the United States. Thus the petty squabble between two magistrates had now expanded to high treason. When the word came to Langley, Captain Grant and his men started up the river, accompanied by Colonel Moody, who had only just arrived on Christmas Day—the day of the trouble. They took with them guns and marines off one of the ships and Judge Begbie, to try the traitors. The river was encumbered with ice, but they succeeded in getting up. They noticed that the nearer they got to Yale and Hill's Bar, the less the trouble seemed, and by the time they got to Hope, they found there was just a miserable squabble between the two magistrates. Finally, the magistrates lost their commissions, the Engineers had an outing, and they did not fire a shot; but it was an instructive affair from one angle. It showed the people from the other side of the line that improper conduct would not be tolerated here.

*Courtesy of C.P.R.*

**Fraser River at Yale, B.C.**

While all this was going on, the main body of the Engineers was coming round the Horn in the "Thames City"—118 non-commissioned officers and men, 31 women and 34 children. To pass away the time, they published a paper every Saturday night, which was read by Captain Luard to the assembled people. It was not printed; it was written on sheets of cardboard—the originals are in the archives at Victoria. The paper contained an account of the events of the voyage—the births and deaths. There were not any marriages. Then there were little gags and jokes; and articles on travel, biography, history, natural history, everything of that kind. And a good deal in the way of original matter—original poetry—or verse at any rate—and original stories.

This gives some idea of the versatility, the varied ability of these men.

Now, owing to the action of Colonel Moody in recommending that the Governor change the capital of the colony of British Columbia from Langley down to New Westminster, the work that the Engineers had done at Langley was all thrown away, and they began to make their permanent camp at Sapperton, now a suburb of New Westminster. The consequence was—the change being made only in February, and the main body being due to arrive on the "Thames City" in April—that when the main body reached Sapperton there was very little done, the advance party having had only a couple of months to work. The site of the camp practically covered the area now taken by the British Columbia Penitentiary.

During the summer of 1859, the Engineers cleared the camp site, between the Fraser River and the crest of the hill. They had probably forty buildings there, including Colonel Moody's residence and the residences of the married officers, the residences of the single officers, quarters for the married men and quarters for the single men; and they had workshops of all kinds for wood and iron-working,—they had main barracks, a theatre, an observatory, and store houses. During the same summer they laid out and surveyed the site of New Westminster, drew the plans, lithographed and printed them. In that year also (1859) they surveyed Hope, Yale, and Douglas, drawing and publishing the plans of those towns; also books were printed in Sapperton by the Royal Engineers' press.

Road construction began, for in 1859 they built a trail leading from the camp out to Burrard Inlet at Port Moody. In the year before, 1858, Governor Douglas had made an arrangement with the miners to build a trail from Douglas through to Lillooet. That had been a rough primitive affair. The Engineers went to work, and they made that in 1859 into a decently passable trail, leading to the Fraser above the canyon. In order to reach the Fraser in the canyon, the Engineers in the same year built a trail from Hope through to Boston Bar, and up to Lytton, keeping to the easterly side of the Fraser. In that year, also, Lieut. Palmer, with another detachment of the Engineers, made a complete exploratory survey of the whole country between Hope and the Columbia River. His report of that work, which is concise and complete, covers some ten closely-printed folio pages. That represented their work for one year, although they had only arrived in April 1859.

The next year, 1860, Governor Douglas made a proclamation in January, permitting pre-emption of land. From 1858 to 1863 on the mainland of British Columbia, Governor Douglas, who had been sworn in at Langley on the 19th of November 1858, was not only Governor, but was also lawmaker. If a law were wanted, and Governor Douglas decided that it was necessary, he sat down and wrote it and handed to the printer, and circulated it; and there was the law. He made this proclamation, and as a result of that, the Engineers—the surveying portion of the Engineers—went to work over the district between Sapperton and Vancouver Harbour or Burrard Inlet, and on the south side of the Fraser River, surveying the land being applied for. They had of course to establish a draughting and record office. In this year, also, they surveyed the towns of Lillooet and Lytton, drew the plans, lithographed and printed them.

The main road to the interior was by way of Douglas and Lillooet. Those familiar with the Harrison River know that there are shoals at certain stages of the water; and so, when a steamer left New Westminster, headed for Douglas, she could only go to the shoals of the Harrison and there discharge her passengers and freight, which had then to be portaged across the shallows. In order to get over that, and make possible a continuous journey by steamer, the Engineers, under Captain Grant, who took eighty men with him, began the construction of large wing dams to control the water on the shoals, so that a steamboat could travel through. However, before the work was finished, the river rose, and being driven from that task, they went to Douglas and began to change the trail of 1859 into a road. The great cry was "Better means of transportation"—thereby, of course, reducing costs; and this trail, which would only accommodate mules, they wanted to turn into a waggon road. In the year 1860, also, the Engineers changed the location of the trail that ran from Yale to Spuzzum. The old trail from Yale—the old Hudson's Bay trail—went by Yale creek in a northwesterly direction, crossed a divide and came down Spuzzum creek in an easterly direction. Governor Douglas determined to build a mule trail along the Fraser from Yale to Spuzzum; it was the first effort to attempt to blast a roadway through those tremendous shoulders of rock. However, the Engineers went to work and did it.

In that year, also, gold was found in the Similkameen country, and the Engineers were called upon to locate a trail so that miners could go from the Fraser River to Similkameen; Sergeant McColl in that summer laid out a trail from Hope to the Similkameen, carrying it over the Cascades 4,000 feet, with no greater single gradient than one foot in twelve. It became known later as the Dewdney trail, because Edgar Dewdney built it in 1860. Next, Governor Douglas was not satisfied with the necessity of using the river to reach Yale and Hope; there was possibility of the river freezing. He wanted to know whether a road could be made from Hope to tidewater. He set the Engineers to work. Captain Parsons in the summer of 1860 explored the whole region between Hope and tidewater, for the purpose of locating a road to serve for occasions when the river might be blocked; and also under Governor Douglas' instructions, he examined into the possibility of utilizing the Chilliwack and Sumas regions (which were then subject to overflow) and protecting them from freshets. At that time, the country being new, when the Governor wanted anything he simply turned to this body of trained men and said "find out the facts for me."

The next year, 1861, was largely a year of preparation. The Engineers were still busy trying to get the road built from Douglas to Lillooet, but people were crying out for still better transportation. They were not satisfied with that road from Douglas to Lillooet. Starting from Douglas, there were twenty-eight miles of land travel. This brought the traveller to Lillooet Lake, where he took a steamer up the lake. There was another land journey to Anderson Lake, and then another steamer to its end. Then a short land trip to Seton Lake. Another steamer on that lake brought him to its end, whence he travelled on to Lillooet by land. It was impossible to speed up traffic under those conditions. So the people said "We want a road that leads into the interior, so that waggons can travel through without any change until the end of the journey, and without waiting for steamers to make connection." Therefore, in 1861 Governor Douglas set the Engineers to work to see whether they could locate a road through the canyon of the Fraser. Now, travellers go through the canyon

*Courtesy of C.P.R.*

**Fraser River Canyon and Old Cariboo Road Bridge, near Spuzzum, B.C.**

in their own (or a friend's) high-powered cars and give no thought to the men who planned the road that was the origin of the present highway. But the Royal Engineers had to hang on as they best could to rocks and trees, striving to get a location where, by means of gunpowder, a road could be built. They went in there first, without any means of transportation at all: just their own hands and feet to make their way with, searching for a practicable route whereby waggons could be brought through that difficult region between Yale and Lytton.

It became plain that the river had to be crossed somewhere and Sergeant McColl was sent out with a party of the Engineers to find the best place—and he found it—the suspension bridge stands there to-day. And that the Royal Engineers made a good choice of a site for a bridge is shown by the fact that when the old Cariboo road went to pieces, after the advent of the C.P.R., and was rebuilt as a scenic highway by the Provincial Government within the last few years, when the Government came to build a suspension bridge (the old one had gone down) they set it at one end, on the very support that the Royal Engineers had chosen! To-day one of the bridge piers rests exactly on the spot that the Engineers chose, and the other is a few feet away only—showing that the work they did was of the substantial kind that stands the test of time.

In this year, also, the Engineers transformed the trail from their camp to Port Moody into a road, which is still in use, the North Road; and Captain Grant with eighty sappers built a road much along the line of McColl's location of 1860, from Hope as far as Skagit Flats about twenty-five miles, on the way to the Similkameen.

Then we come to the next year, 1862. That was the year of the building of the Cariboo waggon road. It has been said that the Engineers built that road. They did not; but they did build two little pieces of it; one, six miles out of Yale, in 1862, and one nine miles out of Spences Bridge in 1863. That is all they built of the whole thing. But at the risk of their own lives they did find out where that road could be put. They made, surveyed and laid out the dangerous and difficult parts, especially along the Fraser and Thompson rivers, and they superintended the construction. During 1862 and 1863, this was a fair portion of their duty—coupled with the work on the Douglas-Lillooet road, because they always kept that going. In 1862, also, the Engineers under Lieut. Palmer explored the whole country between Bentinck Arm and Cariboo, with the idea of finding a shorter route to the Cariboo.

*Courtesy of C.P.R.*

**Coach on the Old Cariboo Trail.**

The last year of the Royal Engineers' work was 1863. In the beginning of that year "The British Columbia Gazette" was established. That was in the charge of Colonel Wolfenden, who has now gone to his reward. But for fifty or sixty years the old colonel was in charge of "The British Columbia Gazette" as The King's Printer. In 1863, the Engineers located the trail from Quesnel through to Barkerville, on Williams Creek, which was then the great gold producing creek. Governor Douglas did not like the existing trail, which was too high, passing over the Bald Mountain, and could be only crossed five or six months in the year. So he wanted a new way; Captain Grant located the trail, and built the whole fifty-nine miles between Quesnel and Barkerville so well that a man could ride it on horseback in a day.

In that year, the Engineers drew the plans, supervised and tested the suspension bridge where it crosses the Fraser twelve or thirteen miles out of Yale. That bridge was built by Mr. Joseph W. Trutch, but it had to be passed by the Engineers. After it was completed, Lieut. Palmer tested it by driving a four-horse team and a loaded waggon, with three tons of goods on it, across the bridge. The bridge stood, and the deflection was less than a quarter of an inch.

In that year also, .the Engineers surveyed, amongst other lands, the original lots that marked the city of Vancouver: lots 184, 185, 186 and 187; George Turner delimited Stanley Park—880 odd acres. It is due to the Royal Engineers that the people of Vancouver, and British Columbia, are blessed with the greatest natural park contiguous to any city in Canada, for the land was reserved by Colonel Moody for military purposes, and was surveyed by his men. A survey was also made of the suburban lots back of New Westminster, and the Council passed a resolution on the 20th of April 1863 as follows:—

"Moved by Councillor A. H. Manson of New Westminster, seconded by John Cooper, that in consequence of the judicious selection of the townsite of New Westminster for the capital of British Columbia by Colonel Moody, R.E., this Council considers it desirable that a space of not less than twenty acres should be reserved in the suburbs now being surveyed, to be called 'Moody Square' in commemoration of the founder of the city, and that the Clerk be instructed to forward a copy of this resolution to the Chief Commissioner of Lands and Works, with a request that the same may be acted upon."

That was done, and is the origin of Moody Square.

But it was not a case of all work and no play with the Engineers. They were out in the summer, in winter they came back to Sapperton, and their camp was then the centre of the social life and activity of the community. They had a social club here. Their theatre was the scene of all kinds of dances and parties and balls, and all that social life which tends, if properly guarded and looked after, to the betterment of a community. The Engineers had a theatrical troupe, and the men of the detachment played comedies and farces and all sorts of dramatic pieces; some of the young fellows took the female parts, and did very well, I understand. One of their plays was "Box and Cox," in which the Surgeon, a big bluff, bewhiskered fellow, played Mrs. Bouncer. That must have been worth seeing.

Summarizing the work of the Engineers, it may be said that they made all the explorations of the country from the time they came here, they surveyed practically all the towns and the country lands; they located and superintended all the trails. They built the North Road, which was originally a trail. They built the Douglas-Lillooet road. They built the Hope and Similkameen road for twenty-five miles; and portions of the Cariboo road. All maps of that time they drew, lithographed and printed in Sapperton. They formed the Lands and Works Department; they established the Government Printing Office. They inaugurated the first Building Society on the mainland; the first social club on the mainland, the first theatre and theatrical society on the mainland. They designed the first public schoolhouse. They designed and built the first Protestant church on the mainland—the Church of St. John the Divine—originally at Langley and now at Maple Ridge. And they designed other churches—the original Holy Trinity, New Westminster, and St. Mary's, Sapperton. They designed the first coat of arms of the Colony. They designed the first postage stamp. They built the first observatory—of course, Captain Cook and Captain Vancouver had temporary observatories, but the first permanent one was built by the Engineers. They fixed its position as 49° 12′ 47″ North latitude, and 122° 53′ 19″ West longitude. They kept the first continuous scientific meteorological observations. They had the first private hospital, and when it was broken up they gave its materials to aid in equipping the Royal Columbian Hospital. The library that they had (which Sir Edward Bulwer-Lytton referred to in his address to them) passed later to the citizens of New Westminster, and it became the nucleus of the library there in the old Mechanics' Institute.

These are the material things. But, apart from that, from the Colonel down, these men were selected men. They were not an ordinary detachment of the Royal Engineers; they were selected men and always took their share in every good work. In everything that went to the upbuilding of the community, as well as in performing their regular duty, Colonel Moody at the head, followed by his officers and men, fully lived up to the motto of their corps "Ubique" and "Quo fas et gloria ducunt."

In October 1863 there came word that the Engineers were to be disbanded. All of the officers and about a dozen of the men returned to England—but the remainder of them settled down here; and through the files of "The British Columbian" of 1863 and 1864, they may be found in civil life as plasterers, plumbers, carpenters, photographers, tailors, shoemakers, undertakers, surveyors, bookkeepers, hotel proprietors—active in every walk of life. In 1863 there were 130 of them here in British Columbia. Thirty years later (1893) there were thirty-four. In 1903 there were twenty-five. In 1909 (that was forty-six years after they were disbanded) there were fourteen. In 1927 the last of them, Philip Jackman, answered his last Roll Call:

In conclusion, looking over the record of the detachment it would seem as if Colonel Moody and his men might have been the soldiers referred to in "Sappers," written fifty years later:—

"I've stated it plain, and my argument's thus,
('It's all one,' says the Sapper)
There's only one Corps which is perfect, that's us,
And they call us Her Majesty's Engineers,
Her Majesty's Royal Engineers,
With the rank and pay of a Sapper!"

The standard that these men strove for in the Colony of British Columbia could not be better described than in another Kipling quotation, from the "Song of the English."

"Keep ye the Law—be swift in all obedience—
Clear the land of evil, drive the road and bridge the ford.
Make ye sure to each his own
That he reap where he hath sown;
By the peace among Our peoples let men know we serve the Lord!"

The descendants of these men are in British Columbia to-day, occupying positions of honour, trust and responsibility in the community, and carrying on in the same sturdy way as their fathers before them.

# THE ANNUAL GENERAL MEETING

WINDSOR HOTEL, MONTREAL

JANUARY 29th and 30th, 1937

## Important Business Discussions

## Montreal Branch Smoker

THE
# ENGINEERING JOURNAL
THE JOURNAL OF
THE ENGINEERING INSTITUTE
OF CANADA



VOLUME XX JANUARY, 1937 No. 1

## The New Year

The President and Council extend to all members of The Institute cordial good wishes for 1937.

We are pleased to record our belief that the year 1936 marked a very definite milestone in Institute affairs.

The aims and aspirations of The Institute toward a unification of the Engineers of Canada in an effective and all embracing professional organization have crystallized in well defined proposals that should find wide acceptance.

The substantial advance made during the past year in trade and employment, the renewed confidence in the ability of the country to recover from the sustained tension of a long depression and the visible signs of returning prosperity make the New Year one of great hope and promise.

The time seems most appropriate for the exercise of a fine spirit of co-operation among Engineers throughout the length and breadth of the Dominion that will open to all a wider opportunity to share in the interchange of professional experience and the advancement of engineering knowledge.

## The Fifty-first Annual General Meeting

The Annual General Meeting for 1937 will convene, in accordance with the by-laws, at Headquarters at eight o'clock p.m. on Thursday, January 21st, for the appointment of scrutineers to canvass the ballot for the election of officers for 1937. It will then be adjourned to reconvene in the *York Room of the Windsor Hotel, Montreal,* at ten o'clock a.m. on *Friday, January 29th, 1937,* continuing on the following day. At this adjourned meeting the following will be the principal items upon the agenda:

1. Nominating Committee 1937—Announcement of Membership.
2. Prizes and Medals of The Institute—Announcement of the several awards.
3. Report of Council for the Year 1936.
4. Treasurer's Report—Report of Finance Committee—Financial Statement.
5. Reports of Other Committees, including that of the Committee on Consolidation.

The principal item under this head will, of course, be the report of the Committee on Consolidation, discussion on which will centre on the proposals for the amendment of The Institute's by-laws which were printed in the December issue of The Journal, pages 550 to 554. In accordance with Section 75 of the by-laws these proposals will be submitted to the Annual General Meeting for discussion. Amendments to the proposals may be put forward at the Annual General Meeting, and the members present have to decide which of such amendments, if any, shall be included with the original proposals and be printed on the ballot paper which will subsequently be sent out to the membership for vote.

Under Section 75 the chairman at the Annual General Meeting appoints a committee to prepare a statement of the reasons for and against the proposals, which statement will accompany the letter ballot.

At the conclusion of the above important business it will be in order to consider and discuss the remaining committee reports, including those of the Papers Committee, Library and House Committee, Board of Examiners and Education, etc.

6. Reports of Branches.
7. Retiring President's Address.
8. Scrutineers' Report on the election of New Officers.
9. Induction of Newly Elected President.

In view of the Semicentennial Celebrations to be held on June 15th to 18th, 1937, the proceedings of this Annual General Meeting will be confined entirely to Institute affairs, the presentation and discussion of professional papers being postponed until that later date.

### Smoking Concert

Members will please note that the Montreal Branch of The Institute are organizing a *Smoker* to be held in the *Windsor Hotel* at *8.15 p.m.* on the evening of *Friday, January 29th.* Such concerts are a feature of the social life of the Branch; out-of-town members and their guests—to all of whom a special invitation is extended—will enjoy the informal character of the occasion, and the opportunity to meet their fellow members under congenial conditions.

## The Registration of Engineers in the United States

The movement for the consolidation of the engineering profession in Canada has now reached the stage at which a definite scheme for co-operation between The Engineering Institute and the Professional Associations has been drawn up, and is before the members of The Institute for their acceptance. At this point it may be useful to glance at the conditions under which the registration movement is progressing in the United States. The difficulties encountered there in arranging for joint action among the various organizations concerned are in many respects like those on this side of the boundary, but a much larger number of authorities and individuals are involved, so that the scale of the movement is almost as impressive as that of the vast engineering achievements in that country.

In 1930 the Federal Bureau of the Census reported the existence of some 226,000 "engineers and surveyors." It is probable, however, that this figure included a considerable number whose work was not really professional in its nature, and who assumed a status for which they were not qualified by training or experience. In 1935 registration of professional engineers was provided for in twenty-nine states having about 40,000 registered engineers. Presumably in these states there were still many engineers who had not registered. At that time, six other states had laws requiring registration of engineers, and such laws were being promoted in nine other states and in the District of Columbia. In the United States, as with us, legislation of this kind is based on the promotion of the welfare and safety of the public, and is a state, not a Federal, responsibility. Its enforcement is in the hands of the State administration. There would appear to be no organizations having constitutions or powers corresponding to those of our Provincial Associations of Professional Engineers, although in some States voluntary societies of professional engineers have been formed. As regards numbers, New York State heads the list with some 10,000 registrations, followed by California, Pennsylvania, and Ohio, each with from three to five thousand.

The first registration act was passed in Wyoming in 1907, but it was not until 1920 that any considerable number of states had laws governing the practice of engineering. The various acts differ considerably in scope and effectiveness. Some classify applicants as to their respective branches of engineering. Two exempt mining and metallurgical engineers. Almost all the acts have already been amended.

The registration boards, of three to nine members, are in most cases composed of professional engineers, appointed by the Governor of the State or the State Department of Education. Many, but not all, States provide for examinations, and in some cases require these to be taken even by college graduates. Examinations, when required, are conducted by State Boards of Engineering Examiners. Practically all acts have the so-called "grandfather" clauses.

The minimum age for registration varies from 21 to 35; four to ten years professional experience are required for non-graduates, and up to four years for graduates of recognized engineering schools. Fees are moderate, from $15 to $25 on registration, with an annual fee ranging from $1 to $15.

There is thus a marked lack of uniformity as regards the requirements and regulations of the various states, causing difficulties which were recognized as early as 1920, and resulted in the formation of a National Council of State Boards of Engineering Examiners. That Council has now established a National Bureau of Engineering Registration, whose purpose it is to draw up and obtain general recognition for uniform standard requirements for a certificate of qualification and for a uniform interpretation of the term "professional engineer." The Bureau's requirements represent the minimum of education and experience that a man must have to become a professional engineer, and it is hoped that its certificate of qualification will be accepted by the various State Boards of Engineering Examiners as entitling the holders to engage in practice in more than one state of the Union. The work of the National Council and its Bureau is thus of real significance as a foundation for the standardization of registration and as an assistance for the individual applicant.

There seems to be no doubt that the state registration of engineers has come to stay in the United States, and the movement will probably develop more rapidly as time goes on. Its progress has already been such as to raise broad questions affecting the whole profession, such as the relationship between the requirements of the State Boards and the curricula of the engineering schools; the relative importance to be attached to graduation from an engineering school, and to years of professional experience; and the part which the engineering societies of national or local scope, can take in the organization of the profession.

In order to plan for the solution of such problems, six of these national bodies, together with the National Council of State Boards of Engineering Examiners, have now established an Engineers' Council for Professional Development. The general object of this council is the enhancement of the professional status of the engineer. It consists of twenty-one members, three being appointed by each of the following bodies: the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners. It thus represents the professional, technical, educational and legislative aspects of engineering.

There are four standing committees, whose duties are indicated by their names. The Committee on Student Selection and Guidance deals with vocational problems and information concerning engineering as a career. The Committee on Engineering Schools investigates degree-conferring colleges and accredits those whose courses and equipment are found satisfactory. The Committee on Professional Training studies the post graduate technical and cultural development of the young engineer. The Committee on Professional Recognition has as its province the definition of prerequisites for admission to professional status, holding that such qualification should be the equivalent of a professional degree and should be normally obtained by the young engineer between his twenty-fifth and thirtieth years. It will be noted that this legal aspect of engineering is only one of the important features of the work of the Council, whose programme is indeed ambitious. Much of its work is now in the preliminary stage, but its method of operation may already be described as the promotion of a general policy by securing the co-operative support of the national organizations directly representing the professional, technical, educational and legislative phases of an engineer's life.

There is, as yet, no definite scheme in the United States for any formal relation between the hundreds of national and local voluntary technical societies and the state-organized agencies for licensing and registration. The work of the Engineers' Council for Professional Development is in some measure directed towards the co-ordination of all these activities. Its programme for the current year has recently been aided by a grant of $16,000 from the Carnegie Corporation of New York. Financial support is also given by the Engineering Foundation, and by three of the Founder Societies. Its formation is a most important step since it constitutes a central and widely representative body, to which may be referred the many questions which must be thrashed out if the professional advancement of engineering is to proceed.

The present situation in the United States has been ably summarized in a recent report of the Russell Sage Foundation, reviewed elsewhere in this issue.* That report confirms the impression that our neighbours realize the need for team work in connection with professional matters. There must be co-operation between the many authorities concerned, including educationalists; representatives of the associations and institutes—many of them highly specialized—which provide for the interchange of professional knowledge; bodies dealing with questions of professional occupation and employment; and those concerned with the legal aspect of professional qualification and registration. It is hoped and expected that such co-operation will be the result of the growth and activity of the Engineers' Council for Professional Development.

## Centenary of the Swiss Society of Engineers and Architects

It is announced that the Centenary celebrations of this organization, the national engineering society of Switzerland, will take place in Berne on the 4th, 5th and 6th of September, 1937. Invitations to send delegates have been forwarded to engineering and technical societies in foreign countries, for whom a special programme is being arranged for the third day of the meeting, including visits to large industrial plants and important public works characteristic of Swiss engineering practice.

The Council of the Society has extended to The Engineering Institute of Canada a cordial invitation to send representatives to these one hundredth anniversary meetings.

## PERSONALS

John J. Rowan, S.E.I.C., who graduated from the Ecole Polytechnique with the degree of B.Sc. in 1935, is now on the staff of the Montreal East refinery of the Imperial Oil Company.

Major H. L. Sherwood, A.M.E.I.C., formerly District Engineer for Military District No. 10, at Fort Osborne Barracks, Winnipeg, Man., is now District Engineer of Military District No. 11, being stationed at Work Point Barracks, Esquimalt, B.C.

R. C. Robson, Jr.E.I.C., who has been designing draughtsman with the B.C. Sugar Refining Company Limited, at Vancouver, B.C., has joined the staff of the Powell River Company Limited, and will be located at Powell River, B.C.

R. L. Weldon, M.E.I.C., has been appointed president of the Bathurst Power and Paper Company Limited, with offices at Montreal, Que. Mr. Weldon graduated from McGill University in 1918, with the degree of B.Sc., receiving that of M.Sc. in 1920. From 1918 to 1919 Mr. Weldon was assistant in the metallurgical department of Peter Lyall and Company, Montreal, and in 1919-1920 he was engineer with the Laurentide Company at Grand'Mere, Que. In 1920-1923 Mr. Weldon was mechanical engineer with the St. Lawrence Paper Mills Limited, at Three Rivers, and in 1923-1925, designing engineer in charge of the design of the Corner Brook mill of the Newfoundland Power and Paper Company Limited. In 1925 Mr. Weldon became chief engineer and assistant mill manager of the same company, holding that position until 1928 when he joined the staff of the International Power and Paper Company Limited, of Newfoundland, as manager of manufacturing and director of the Newfoundland activities of the International Power and Paper Company at Montreal and Corner Brook, Nfld., and in 1930 he was transferred by the company to New York, as chief engineer.

J. G. Schaeffer, A.M.E.I.C., has been appointed sanitary engineer for the Saskatchewan Department of Public Health, Regina, Sask. Mr. Schaeffer graduated from Queen's University with the degree of B.Sc. in 1923, and was subsequently, until 1928, on the staff of the city engineer of Regina, Sask. From 1928 until 1931 he was on the staff of Underwood and McLellan, consulting engineers, Saskatoon, in charge of the design and construction of water works, sewage disposal plants, and street improvements in Manitoba and Saskatchewan, and in 1932 Mr. Schaeffer was on the staff of the city engineer of Saskatoon. In 1933 he entered private practice, specializing in municipal engineering service, but gave this up in 1935 to join the staff of the Department of Public Works, Canada, in connection with bridge and wharf construction in the provinces of Saskatchewan and Ontario. In July, 1936, Mr. Schaeffer became resident engineer with the Department of Highways of Saskatchewan, but resigned to accept his present appointment.

## Elections and Transfers

At the meeting of Council held on December 18th, 1936, the following elections and transfers were effected:—

*Members*

HALL, Henry Monroe, A.B., (Dartmouth Coll., Hanover, N.H.), mill supt. and wire rope engr., Canada Wire and Cable Co., Toronto, Ont.

McBRIDE, Wilbert George, B.Sc., (McGill Univ.), professor of mining engineering, McGill University, Montreal, Que.

*Associate Members*

LASH, Alfred William, M.Eng., (Univ. of Sheffield), hydraulic engr., Ontario Paper Co. Ltd., Thorold, Ont.

SCOTT, Clarence Whiting Harmer, B.Sc., (Queen's Univ.), dftsman., Canadian Bridge Company, Walkerville, Ont.

*Juniors*

HORTON, Everill Blackwell, B.A.Sc., (Univ. of Toronto), machinist, Link-Belt Ltd., Toronto, Ont.

ROGERS, Joseph Victor, B.A.Sc., (Univ. of B.C.), asst. engr., Churchill River Power Co., Island Falls, Sask.

*Transferred from the class of Associate Member to that of Member*

MACDONALD, Albert Edward, B.Sc., (N.S. Tech. Coll.), M.Sc., (McGill Univ.), professor of civil engrg. and head of the dept. of civil engrg., University of Manitoba, Winnipeg, Man.

REID, John Herbert, B.Sc., (McGill Univ.), gen. supt., Trinidad Electric Co. Ltd., Port-of-Spain, Trinidad, B.W.I.

*Transferred from the class of Junior to that of Associate Member*

HOOPER, William Henry, B.Sc., (McGill Univ.), elect'l. engr., coil dept., Canada Wire and Cable Co. Ltd., Toronto, Ont.

*Transferred from the class of Student to that of Associate Member*

COLEMAN, Sheldon W., F/Lieut., R.C.A.F., B.Sc., (McGill Univ.), Adjutant, No. 8 (G.P.) Squadron, c/o Dept. of National Defence, Ottawa, Ont.

DUNLAP, Clarence Robert, F/Lieut., R.C.A.F., B.Sc., (N.S. Tech. Coll.), Camp Borden, Ont.

FISHER, Charles Boddy, B.A.Sc., (Univ. of Toronto), M.Eng., (McGill Univ.), engr. in charge, radio receiver engrg. dept., Northern Electric Co. Ltd., Montreal, Que.

PHELAN, Michael Alexander Austin, B.Sc., (Queen's Univ.), mgr., Noranda Office, Peacock Bros., Noranda, Que.

*See page 31.

TREBLE, Harold Edison, B.Sc., C.E. (1926), B.E.E. (1927), (Univ. of Man.), Topographical and Air Survey Bureau, Ottawa, Ont.

*Transferred from the class of Student to that of Junior*

BENNY, Walter Robert, B.Eng., (McGill Univ.), transitman, C.P.R., Smiths Falls, Ont.
BERRY, Melville Douglas, B.Sc., (Univ. of Man.), 31 Stanhope Ave., Toronto, Ont.
LEIGHTNER, Donald Benjamin, B.Sc., (Univ. of Man.), engr., Canadian Westinghouse Company, Hamilton, Ont.
SILLITOE, Sydney, B.Sc., M.Sc., (Univ. of Alta.), radio engr., Northern Electric Co. Ltd., Montreal, Que.
STRATTON, Leslie Robertson, B.Sc., (Univ. of N.B.), asst. engr., Saint John Harbour Commission, Saint John, N.B.
WILLOWS, Fred, B.Sc., (Univ. of Man.), mine engr., Rahill Red Lake Mining Co., Red Lake, Ont.
YORK, Frederick Gilbert, B.Eng., (McGill Univ.), asst. to line supt., Ottawa Hydro Electric Commission, Ottawa, Ont.

*Students Admitted*

BUDDEN, John Hastings, (McGill Univ.), 3460 Simpson St., Montreal, Que.
COOK, Kenneth Gilbert, (McGill Univ.), 381 Prince Albert Ave., Westmount, Que.
DAVIS, Eliot Robertson, B.Sc., (Univ. of Man.), 548 Prince Arthur West, Montreal, Que.
DEGUISE, Yvon, (Ecole Polytechnique, Montreal), 58 Church Ave., Verdun, Que.
FERGUSON, Jack Andrew, (Queen's Univ.), 303 University Ave., Kingston, Ont.
HARLEY, Gordon G., (McGill Univ.), 2028 Victoria St., Montreal, Que.
HENSELWOOD, Edward Wilton, (Univ. of Man.), 139 Leila Ave., West Kildonan, Man.
LAMB, Hugh, Jr., (McGill Univ.), 1426 Pierce St., Montreal, Que.
NEUFELD, Cornelius, B.Sc. (C.E.), (Univ. of Sask.), 1328 Elliott St., Saskatoon, Sask.
RICHER, Baxter Dallard, (Ecole Polytechnique, Montreal), 5854 Durocher Ave., Montreal, Que.
SEIFERT, Harold Lorne Bain, (McGill Univ.), 1512 St. Mark St., Montreal, Que.
SENTANCE, Lawrence Crawley, B.Sc. (M.E.), (Univ. of Sask.), 414 Albert Ave., Saskatoon, Sask.
THOMSON, John Alexander, (McGill Univ.), 3653 University St., Montreal, Que.
WESLEY, William Grant, (McGill Univ.), 1445 Van Horne Ave., Outremont, Que.

## FIFTY-FIRST ANNUAL MEETING

### WINDSOR HOTEL, MONTREAL

### JANUARY 29th and 30th, 1937

**Dominion Square, Montreal.**

## SEMICENTENNIAL COMMITTEE

**A. Cousineau, A.M.E.I.C.**
**R. L. Dobbin, M.E.I.C.**
**J. M. Fairbairn, A.M.E.I.C.**
**R. H. Findlay, M.E.I.C.**
**F. S. B. Heward, A.M.E.I.C.**
**J. L. Busfield, M.E.I.C., Chairman**

### CALENDAR

**With this issue of The Journal there is being distributed to all Corporate Members of The Institute a six-month calendar especially featuring the dates of the Semicentennial. It is hoped that this calendar will be prominently displayed by members and used as a reminder that they have a date to keep in June.**

### TECHNICAL PAPERS

**Johnstone Wright, M.I.E.E., Chief Engineer of the Central Electricity Board, London, England, will describe the difficulties confronting the Electricity Industry in Great Britain as a result of piecemeal pre-war development and reviews the steps taken to reorganize the generation side of the Industry in that country on progressive lines to provide for the rapidly expanding demand for electricity. Reorganization is based on the co-ordination of generating resources through a comprehensive network of interconnecting trunk lines, and the paper deals not only with the principles under which the system is operated, controlled and financed, but also some of the general technical aspects of the transmission system popularly known as the "Grid."**

**J. H. Parkin, M.E., M.E.I.C., F.R.Ae.S., of the National Research Council, Ottawa, Ont., will present a paper dealing with the different factors involved in the establishment of an inter-continental service by heavier-than-air aircraft across the North Atlantic. Factors discussed include—nature of service, barriers and methods of surmounting them, possible routes, organization of route and types of aircraft.**

**J. C. Bernier, B.A.Sc., E.E., Assistant Professor of Physics, Ecole Polytechnique, Montreal, who has been engaged for some years in research work on the cathode-ray system of television, and electron optics, will give a demonstration and explanation of the present principal systems of high definition television communication and a discussion of their relative merits.**

### VISITORS

**The Royal Aeronautical Society will be represented by its President, Mr. H. E. Wimperis, who has been in charge of research work for the Air Ministry for many years.**

## Committee on Consolidation

### Report for December, 1936

With the exception of the submission of its official report to the Council of The Institute for presentation to the Annual Meeting, the Committee on Consolidation has finished its work for the year 1936 and the results of its efforts have been placed before the profession.

Since the Annual Meeting of February 5th, 1936, the Committee has held nine regular meetings, one joint meeting with the Dominion Council and representatives of Provincial Associations and Corporation, two joint meetings with the Council of The Institute, and has been represented at the plenary meeting of the Council held on October 16th and 17th to consider its proposals regarding revisions to the By-laws of The Institute.

In accordance with its policy of keeping the members fully informed with regard to the progress being made, reports of these meetings have appeared in The Journal each month and have also been made available to those members of the Provincial Professional Associations who are not at present members of The Institute.

During the year the Committee has carried out the following:—

(*a*) The preparation of the revisions to the By-laws of The Institute considered essential to effect closer co-operation between The Institute and the Provincial Professional Associations.

(*b*) Suggested revisions to certain other clauses of the By-laws not directly related to Consolidation but which it appeared advantageous to introduce at this time.

(*c*) The re-arrangement and re-numbering of the By-laws in a proper and logical sequence for more ready reference by the members. (This re-numbering to take place after the ballot.)

(*d*) The preparation of a standard form of Agreement between The Institute and a Provincial Professional Association, to implement the co-operation provided under the new By-laws.

(*e*) The drawing up of a simplified form of "Application for Admission to The Institute" by a member of a Provincial Professional Association.

The above documents are now before all members of the profession for their consideration.

It will be recalled that at the last Annual Meeting the status of The Institute's Committee on Consolidation was altered by the addition of two representatives from the Dominion Council of Professional Engineers, and that in effect it became a National Committee with the appointment of Mr. C. C. Kirby and Mr. A. B. Crealock to its membership. These representatives of the Associations have made their contribution to the findings of the Committee on behalf of the organizations they represent, and at the same time they have performed the function of keeping the Associations advised of the progress of the deliberations of the Committee.

Under date of December 19th, 1936, Mr. C. C. Kirby, in his capacity as President of the Dominion Council of Professional Engineers, submitted a report on the By-law proposals of the Committee to the various Professional Associations for their consideration and such action as they may find advisable at this time.

With reference to the ballot on the proposed revisions to the By-laws which will come before the membership early in the New Year, we would strongly urge each individual member to carefully investigate the possibilities of these proposals as they apply to himself and to the profession as a whole, and, on the basis of the information which has been made available to him, to express his opinion through his vote. Every member of The Institute, no matter what his opinion, is strongly urged to express it through his ballot.

In connection with Section 7 (*b*) of the Committee's proposed revision of the By-laws, which the Plenary Meeting of the Council proposed to amend by the insertion of the phrase, "who is required by law to be a member of that Component Association," resolutions are being received from a number of Branches of The Institute favouring the Section as originally drawn by the Committee. So far only one Branch favours Council's amendment. Of the Provincial Professional Associations, six support the proposals of the Committee on this Section, and two have expressed no opinion.

The following communication submitted over the signatures of twenty-four members of the Quebec Branch will be of interest, coupled as it is with a resolution by the Executive of the Branch approving this letter and respectfully recommending to Council that it re-consider the decision of the Seventh Plenary Meeting (by a vote of 13 to 8) as regards Section 7 (*b*) of the proposals.

Quebec, P.Q.
December 1st, 1936.

To the Council,
The Engineering Institute of Canada,
2050 Mansfield Street,
Montreal, P.Q.

Gentlemen:—

Under date of September 21st, 1936, we, the undersigned members of The Engineering Institute of Canada (Quebec Branch), formally submitted to you the proposals drafted by the Committee of Consolidation for additions to, amendments of or repeal of existing By-laws of The Institute, in accordance with Section 75 of the By-laws.

By the said letter, we authorized, delegated and directed the Committee on Consolidation, or a majority thereof, to act for us and in our stead, in withdrawing these proposals, accepting any changes suggested *except as to proposed Section 7 (b)* or insisting on the original form, as it may decide.

The proposed Section 7 (*b*) read as follows:—

> "7 (*b*). No person residing in any province in which there is a Component Association shall be admitted as a member of The Engineering Institute of Canada, unless he be a corporate member of such Association."

At the Plenary Meeting of Council, held on October 16th and 17th 1936, the said proposals were discussed and we were duly informed of the opinions and suggestions then approved by resolutions of Council. We have noted that the said Section 7 (*b*) was revised by Council to read:—

> "No person residing in any province in which there is a Component Association *who is required by law to be a member of that Component Association,* shall be admitted as a Member of The Engineering Institute of Canada, unless he be a corporate member of such Association."

Please be advised that we cannot accept this revision of the proposals and that *we hereby insist on the original form.*

We are taking this attitude because we know that Council were divided in reaching their decision as regards the above revision and because the principles involved by the said revision or amendment are not sound, in our opinion, and, therefore, cannot bring anything but detriment to The Institute and the profession.

Since the incorporation of our Society, 50 years ago, the purpose of which was the organization of Canadian engineers from a strictly professional point of view, widely divergent views about the standards of admission have continuously divided the membership in two schools of thought which are properly described by the following quotation which is taken from a paper read by Prof. C. H. McLeod, Secretary of our Society from 1891 to 1916, before the Third Conference, Committee on Engineering Co-operation at Chicago, on March 29th. 1917. Professor McLeod stated:—

"Chief amongst problems of interest to Canadian engineers is the question of legislative protection, in connection with which we have, as elsewhere, those who do not desire any (however remote) suggestion of legal control and those who, on the other hand, would wish to see established the most exclusive protection in the practice of their profession.

"The exponents of the *wide open door* are probably those engineers who occupy the important positions, either as consulting practitioners or as official representatives of large corporations. Those, however, who would limit the practice of engineering by legislative enactments, whether they so express themselves or not, are unquestionably in the majority. This majority desires such protective legislation as is elsewhere accorded to the legal and medical professions . . . That legislative control of engineering practice in Canada is one of the problems which we shall have to face and that in the near future, is, to my mind, beyond peradventure." (See "Canadian Engineer," Vol. 32, April 19, 1917. "How Canadian Engineers Organize.")

Professor McLeod was right.

In 1928, at the Second Plenary Meeting of Council, Mr. F. P. Shearwood, as chairman of a "Committee on Grades of Membership," presented a report which indicated again these two schools of thought, one carrying the suggestion that the scope of the membership of The Institute should be widened so as to admit men who cannot be considered fully and broadly educated engineers, but whose experience in engineering work gives them a valuable technical knowledge, and the other holding for the maintenance of a high standard of educational and practical requirements for admission. (See Report of the Committee on Consolidation, January 1936.)

In 1930, Mr. S. G. Porter, in the very able and elaborate report of the "Committee on Relations" of which he was chairman, recommended "That steps be taken to secure the necessary amendments to the By-laws so that membership or registration in a Professional Association be one of the requirements for admission to Corporate Membership in The Engineering Institute of Canada for all applicants residing in a province where an Engineering Professions Act is in effect." But, on the other hand, in the discussion of this subject, Mr. P. L. Pratley, one of the very few dissenting voices at the meeting, stressed his opinion that educational effort and legislative function should be divorced. He wanted The Institute for men in offices of large companies who have no intention of practising engineering as a profession and did not need licenses to practice. (See "The Journal," March 1930, page 212.)

We claim, and this view has always been held by the Quebec Branch, that The Institute is the National Professional Society of Canadian Engineers and that there is no reason why engineering craftsmen, however valuable may their experience and services be to engineers, should be admitted in The Institute.

Law clerks, who often are specialists in varied branches of law and civil procedure and render most valuable services to the prominent lawyers by whom they are employed, are not admitted in the Canadian Bar Association. Trained nurses, hospital orderlies, dieticians, druggists, etc., although most precious aids to the medical profession, are not admitted in the professional associations inter-linked through the Medical Council of Canada. And, architects do not admit in their Royal Canadian Institute, the draftsmen who work in their offices, the dealers in building materials and the contractors with whom they are in daily contact and who co-operate with them.

However, these opposite views have repeatedly come in conflict throughout the life of our Society. The question of the admission of members has been a never ceasing source of trouble and was the stumbling block which was found in the way of all the most important special Committees of The Institute during the last fifteen years, such as the Committee on Policy, on Relations, on Development. And now, the splendid efforts of the Committee on Consolidation, towards crystallizing a clearly defined engineering profession in this country, are about to be lost if this same obstacle cannot at last be removed.

It is not our intention to deprive The Institute of any of its prerogatives and we hold that The Institute is not abandoning any of its rights in writing in its By-laws that its future members shall comprise registered professional engineers only.

It is a fact that the provincial Associations were incorporated at the instigation and with the support of The Institute for the purpose of fulfilling a function which The Institute, as a Dominion-wide body, could not legally perform according to our Canadian Constitution, namely the legislative control of the practice of the engineering profession.

This function implies the recognition of the engineer professionally and the concept of professional membership must of necessity find acceptance by The Institute. Otherwise The Institute would have caused, through the formation of the provincial Associations, a dismemberment of the profession to its own detriment as well as to that of the profession in the National sense.

We therefore claim that The Institute has willingly entrusted the provincial Association with the duty of admitting, in its stead candidates to professional membership and that, by accepting provincial registration as a prerequisite for admission in its ranks, it is simply enjoying the consequence of its own free act which caused the birth of the Associations.

Furthermore we cannot see our way clear to accept the suggestion that The Institute can go its way and develop along its own lines independently of the provincial Associations because such a course of action would mean nothing less than the repudiation by The Institute of its history for the past half century during which time it has been truly and exclusively representative of the engineering profession within the boundaries of our Dominion and has thus won the respect of the other professional organizations, at home and abroad; such a procedure would mean suicide.

Since the vast majority of professional engineers want to build up a truly integrated profession throughout Canada and unless this be done promptly through The Institute, the Dominion Council of Professional Engineers is bound to become a permanent organization and will then have to assume all the educational and social functions which The Institute has heretofore provided for the profession. In that event, The Institute would no longer be the accredited National body representing the Engineering Profession and could at best be looked upon as a semi-professional organization or service club.

We have endeavoured to express very frankly our viewpoint on a subject which we consider to be the crux of the problem before us and we are convinced that, by insisting on the original draft of Section 7 (*b*) being submitted for ballot to the membership, we are acting in the very best interests of The Institute and the Profession.

Copies of this letter are being sent to the Committee on Consolidation and to all Branches, as a matter of information.

Yours very truly,

(Issued over the signatures of twenty-four members of the Quebec Branch.)

The following resolution was passed at the Seventeenth Annual Meeting of the Association of Professional Engineers of British Columbia on December 5th, 1936:

> "That the earnest efforts of the British Columbia Council on Consolidation during the last two years have caused the partial exclusion or neglect of the usual activities in B.C. and it is essential to return to these activities in the forthcoming year, and further that this meeting wishes the very best of success to The Engineering Institute of Canada and the sister Associations in their endeavour to form a truly national representative body. And further as the B.C. Association Council, to the best of its ability, has put forward its ideas consistently, both in writing and by visits to Hamilton, Toronto and Montreal, that this meeting considers that any further practical effort at consolidation should be sympathetically considered by the incoming Council."

The above indicates the great interest and activity which the Association of Professional Engineers of British Columbia has taken towards Consolidation during the past two years, and their sympathetic support of further practical efforts to that end.

In conclusion, all members of The Institute who can do so, are strongly urged to attend the Annual Meeting in Montreal on January 29th and 30th. when these important matters will be discussed in detail.

GORDON McL. PITTS,
*Chairman*

## Not Guilty

When discussion of the engineering attitude is extended to the point of blaming science and technology for the world's present-day dislocations, it is time for a fitting retort. Such retort was made by Karl T. Compton, head of Massachusetts Institute of Technology, in answering President Roosevelt's recent letter calling on the engineering colleges to equip their students for meeting their social responsibilities. The President charged that the impact of science and engineering upon human life has caused unemployment, bankruptcies and relief; he asserted that engineering in addition to creating tools of production must co-operate in designing "accommodation mechanisms to absorb the shock" of this impact; better balance of college curricula, he said, will enable coming generations of engineers to meet this responsibility. Dr. Compton rejects the indictment; he points to the great social advances that have been made possible by increased productive power and to the improved standards of life which we enjoy—all of them achievements of science and engineering. Moreover, he pointed out that these same arts are continually at work developing new products, new industries, new employment and improved health and welfare. Breadth of knowledge and outlook are no less needed among business leaders, economists and politicians than among engineers, Dr. Compton stated. Finally he urged that the government itself give more support to science and encourage its activities in government, industry and educational institutions. In brief, he restated effectively the known fact that science and technology have helped and not hurt the human race, that they constantly enlarge its productive performance with decrease of toil and open up to all a larger and more effective life.

—*Engineering News-Record.*

# Recent Additions to the Library

### Proceedings, Transactions, etc.

Institution of Structural Engineers: Specification for concrete pile-driving, October, 1936.
American Society for Testing Materials: Standards, 1936.

### Reports, etc.

*Canadian Radio Broadcasting Commission:* Annual report for the year ended March 31st, 1936.
*Institution of Engineers, Australia:* Memorandum and Articles of Association.
Rules and By-laws—Melbourne Division.
*Corporation of the County of Wentworth, Ontario, Road System:* Annual Report, 1936.
*Canada, Department of Labour:* Report for the year ending March 31st, 1936.

### Technical Books, etc.

Cyanidation and Concentration of Gold and Silver Ores, by John Van Nostrand Dorr (*McGraw-Hill Book Company, New York*).
Thermodynamic Properties of Steam, by Joseph H. Keenan and Frederick G. Keyes (*John Wiley and Sons, New York*) (*Renouf Publishing Company, Montreal*).

# BULLETINS

*Portable Drills.*—A 12-page bulletin received from the Worthington Pump and Machinery Corporation, Harrison, N.J., describes and illustrates the company's Rockmaster portable drill, especially adapted for down hole drilling, line drilling, hillside drilling, breast hole drilling, side hole drilling and snake holing. It is furnished with pneumatic tires so that the rig may be collapsed for towing behind an automobile, a truck or a tractor.

*Screw-Feed Drifters.*—The Worthington Pump and Machinery Corporation, Harrison, N.J., have issued a 4-page leaflet, describing their screw-feed drifters, which are made in three models, for light, medium and heavy duty.

*Silent Chain.*—A 12-page booklet received from the Hamilton Gear and Machine Company, Montreal and Toronto, contains data regarding their industrial silent chain for power transmission. It gives a simplified method for designing a chain drive with tables to determine outside diameter of sprocket, and the length of chain, and covers the installation and care of silent chain drives.

# BOOK REVIEWS

## Hydraulics

*By Charles W. Harris. John Wiley and Sons, New York. (Renouf Publishing Co. Montreal). 1936. 6¼ by 9¼ inches. 220 pages. $2.75. Cloth.*

Reviewed by Dr. T. H. Hogg, M.E.I.C.*

It is usually considered that hydraulics is not an exact science and that its rational formulas must always be revised to conform with actual results as indicated by experiment and practice. The author of this book takes the view that most of the problems of hydraulics lend themselves to logical treatment. To quote from the preface: "The medium is homogeneous, and the major laws exact... An empirical method under this condition is a subterfuge. It may be tolerated in a specialized field or as a handbook expedient, but... the real student has but passing interest in an unsolved paradox."

The quotation and the length of the volume will suggest that the book is primarily a student's text book. It is a text book of unusual merit, because of its approach to the solution of each problem through fundamental principles. Naturally, many old and valued empirical formulas and generally empirical methods of attack receive short shrift. A course of study in elementary hydraulics, based on the text, would equip the student with a very valuable instrument for use in his professional work.

The book merits study also by the practising engineer, for within its limited scope he will find a considerable amount of valuable data and, above all, a simplification of methods of attack on common problems that will prompt him to discard such empirical debris.

An improvement for practical purposes could be effected by enlarging some of the diagrams, by giving specific references at times, and by extending the space allotted to certain important subjects, even at the expense of cutting down that given to others. For example: under Water-Hammer, the subject of time closure is treated in less than half a page, and backwater and drop-down curves are covered in less than one page. These two problems are of such great practical importance that more space is merited if for no other reason than to impress their importance on the student.

The figures and tables are well prepared and the book is well indexed.

*Chief Hydraulic Engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ontario.

## Design of Reinforced Concrete Structures

*By Dean Peabody Jr. John Wiley and Sons, New York (Renouf Publishing Company, Montreal). 1936. 6 by 9¼ inches. 457 pages. $4.00. Cloth.*

Reviewed by Brian R. Perry, M.E.I.C.*

The author of this book is associate professor of structural design at the Massachusetts Institute of Technology. He states clearly that the volume has been written as a text book to be used in connection with a course of lectures in reinforced concrete design. With the background of M.I.T. we should expect just such a text book as is presented, a complete discussion of the fundamentals of the subject; it fills a need not taken care of in other such books because it is restricted to these fundamentals. Its purpose is not confused by the addition of a mass of information designed to add to its usefulness as a reference book.

It may seem that a few items such as reinforcement for shrinkage conditions, the alternative methods of approach to features such as continuity, etc., might have been given more detailed explanation. In such cases it would appear that the author has rigidly avoided including anything but essentials to basic understanding of the subject. Enthusiasm for detail and developments of special cases has rendered many text books on concrete clumsy, unsuitable and confusing to the reader who most requires them.

The most attractive feature of the book is the author's obvious desire to instil into his students (or readers) the basic idea that concrete design is not a precise procedure but is a matter of opinion based on available information. The various features of such design are merely the accepted rules established by various responsible bodies who determine that very necessary standard known as "best modern practice." He quotes all necessary data and assumptions; refers to various codes and specifically chooses one code for the application in view, often stating the reason for the recommendation but inferring that the choice may be to some extent a matter of personal preference. With this background he develops the application of the formulae of mechanics to reinforced concrete. He repeatedly refers to "commercial design" as being not necessarily a precise procedure and gives the logical reasons for this condition. With the thorough grounding in fundamentals which is given, and the development of this critical attitude toward the data on which the design processes are based, his students and readers should avoid the greatest danger for junior or casual designers who have been taught to accept published texts or codes as being statements of fact from which there can be no departure. When they see the variations that exist in practice there is a possibility that they might discard restrictions somewhat indiscriminately.

Because the text deals with fundamentals it should not be inferred that it is elementary and of use only to students. The theoretical principles for all ordinary building design are developed in a logical sequence and clear illustrative problems are worked out for each phase. It covers all such requirements of structural design including fundamentals of continuity and rigid frames, arches and retaining walls.

A perusal by the seasoned designer is warranted, if only to bring a realization of the aggregate of change and development in the past two decades, and the changes that are still proceeding. There is a great divergence of opinion and no accepted practice for the treatment of such subjects as Moment of Inertia of Concrete Sections; Deflection and Time Flow; Torsion; Two-way Slabs, etc., in this book these subjects are discussed freely in the light of this divergence of opinion and their theoretical development is handled more clearly than in most available references.

The index is somewhat scanty and the bibliography is rather limited for a book of reference. Used for the intended purpose as a text book, this deficiency would not be serious.

*Consulting Engineer, Montreal.

## Mechanical Engineers' Handbook

*Robert T. Kent, Editor in Chief and 28 contributors. John Wiley and Sons, Inc., New York (Renouf Publishing Company, Montreal). 1936. 5⅝ by 8⅝ inches. $5.00. Cloth. 1,254 pages.*

The famous "Kent" handbook has for over forty years been the "bible" for mechanical engineers the world over. Now comes an eleventh edition, designed to meet their specific needs even more fully.

A change has been made in the set-up of the book which is now divided into two volumes, one dealing with power and its applications of interest to the mechanical engineer; the other, methods in design and shop practice. These volumes may be purchased separately or in combination, and the engineer will now find all necessary information in each field conveniently gathered in one compact volume. This review will deal solely with the power volume, since the design and shop practice will not appear until the spring of 1937.

In line with the new plan of design of the Wiley Engineering Handbook Series, of which the power volume Kent is number II, this volume measures 5⅝ by 8⅝ inches. The increased size of the book permits the use of large, clear type, illustrations and diagrams a feature which greatly enhances the practicality of the book.

There are seventeen sections in the power volume, followed by an unusually complete index. Section I, Air, includes a description of the properties of air, a discussion of the flow of air, and a full treatment of air compression, including fans and blowers. Section II, Water, covers the fundamentals of hydraulics including material on flow of water, turbines, pumps and pumping engines. Section III, Heat, offers unusually complete handbook treatments of the measurement of heat, heat transmission, evaporators and evaporation, dryers and drying, heat insulation and thermodynamics, and a section on combustion and fuels follows.

Section V gives the necessary information concerning steam and Section VI applies these principles of the action of steam to the steam boiler, offering thorough descriptions of the various types of steam boilers, their performance, construction and other important data. Section VII follows with a discussion of important data concerning the steam engine, while Section VIII covers the types, performance, etc., of the steam turbine. Section IX deals with condensing and cooling equipment, and Section X with refrigeration and ice making.

Section XI presents a very complete summary of the essential information in the field of heating, ventilating and air conditioning. Section XII devotes space to a discussion of internal-combustion engines, including Diesel, gas and gasoline engines. Gas producers receive full attention in Section XIII. Section XIV is entitled Transportation, and covers railroad engineering, automotive vehicles and aeronautics. Section XV gives a brief summary of the fundamentals of electric power, offering much needed information on purchased power, generated power, conversion equipment, switchboard equipment, batteries, power factor and power distribution. The final section gives a complete and accurate set of mathematical tables of vital importance to the mechanical engineer.

## Electrical Engineers' Handbook

*Harold Pender, Editor-in-chief, William A. DelMar, and Knox McIlwain, Associate Editors-in-Chief. John Wiley and Sons, New York (Renouf Publishing Company, Montreal). 1936. 5⅝ by 8⅝ inches. $5 00. Cloth. 1,300 pages.*

The third revised edition of the famous Pender's Electrical Engineers' Handbook appears in a different form than heretofore. Material fundamental to all engineering (i.e. mathematics, physics and chemistry) has been removed to a separate volume—Eshbach's "Handbook of Engineering Fundamentals" published last September. This edition has also been separated into two volumes, one dealing with electric power and the other with electric communication and electronics, which are listed as Volumes IV and V in the new Wiley Engineering Handbook series.

The electric power volume has been consolidated into nineteen sections, each dealing with a general topic. The treatment accorded to each topic has been handled so that each receives attention in accordance with the importance of the subject in relation to other subjects in the field. Controversial matters have been avoided. The section headings include: mathematics, units and symbols; properties of materials; electric circuits and electric lines; resistors, reactors, magnets; measurements and measuring apparatus; principles of electrochemistry; batteries; direct-current machines; alternating current machines; transformers; converters and rectifiers; switching control and protection; power stations and substations; power transmission and distribution; lighting and heating; industrial applications of motors; transportation; electrochemical and electrothermal industries; electricity on the farm.

The electric communication and electronics volume covers the whole field of communication, including telegraphy, telephony, radio broadcasting, point-to-point radio telephony, facsimile transmission and reception, public address systems, sound motion pictures, aviation radio and television. It gives complete information on electronic control systems, for manufacturing processes, theatre lighting, welding, blind-landing of aeroplanes, etc. Materials are arranged in tabular form, with the mechanical and electrical properties listed with each material so that all information about the material is available at a glance. Complete design information is included on all parts of the system: resistors, inductors, capacitors, microphones, loud-speakers, transformers, wave filters, amplifiers, modulators, detectors, oscillators, antennas and power supply units, as well as articles on complete transmitters and receivers. The first section of the book contains complete mathematical tables, etc., logarithms, trigonometric, exponential and hyperbolic functions, decibels, etc., and in the section dealing with electron tubes exhaustive tables are given, including the new metal tubes, thyratrons, photo-sensitive, cathode ray and x-ray tubes. The book is profusely illustrated.

The volume also includes tables of sound absorptive and insulating properties of building materials; complete descriptions of the new facsimile and television systems; including detailed discussion of the special elements required, and a complete discussion of electricity as used in medical work.

## The Professional Engineer

*By Esther Lucile Brown. The Russell Sage Foundation, New York. 1936. 8 by 5½ inches. Cloth. 75 cents. 86 pp.*

This is one of a series of "studies of social conditions" carried out by the Foundation established in 1907 by Mrs. Russell Sage "for the improvement of social and living conditions in the United States of America." The authors of these Foundation studies are members of its staff, or special workers, who have the benefit of the criticism and advice of their colleagues in the organization.

The author of the report now reviewed has covered a wide field in a few pages. This has been possible largely because her work has been based on sound fundamental ideas. She realizes, for instance what is perhaps the greatest source of difficulty in organizing an "engineering profession" namely that "at one end of the scale engineering merges imperceptibly into pure science, and at the other into business."

The report first discusses engineering education and its development, emphasizing the fact that not all who call themselves engineers have occupations which can be recognized as engineering in a professional sense. It is important to distinguish clearly between technicians and professional engineers as regards the nature of their work and the kind of training necessary to qualify them for it. In the United States some one hundred and sixty engineering schools offer courses of professional character and confer degrees; they have over seventy thousand students, and they send out some seven thousand graduates annually. This imposing array of professional schools may be contrasted with the much smaller number of technical institutes whose training fits "for those vocations lying between the skilled crafts and the kinds of engineering work that require prolonged scientific preparation," schools of a type of which more than one hundred and fifty exist in Britain and more than one hundred in Germany. This disparity seems to indicate a need which should be met.

As regards the advancement of professional standards, recognition is given to the leadership shown by the great number of American engineering societies, headed by the outstanding organizations of national scope, whose work has now resulted in the formation of the Engineers' Council for Professional Development.

A well deserved tribute is paid to the achievements of the Society for the Promotion of Engineering Education, the body which, with the aid of the Carnegie Corporation, was the first to make a systematic study of professional engineering training in the United States.

Passing to a survey of the available statistics regarding the number of engineers, the demand for their services and their earnings in various branches of the profession, Dr. Brown points out their rapid growth in numbers, traces the effect of the depression upon their earnings, and very justly remarks that "engineers and architects are likely to be more at the mercy of economic variations than are the professions that offer their services in the main directly to individuals." It is somewhat surprising to find that in her opinion "information concerning salaries is more extensive and authoritative for engineers than for most of the other professional groups." Engineers as a class are evidently more communicative than some of us have believed.

The figures quoted are analyzed and discussed. Space will not permit even a summary of the interesting results which are given, but the present reviewer feels bound to state his full agreement with the author's opinion that an engineer's chances of earning a high salary are greatly reduced if he cannot combine with his technical skill a generous degree of capacity to deal with men and affairs.

The report concludes with some timely comment on the change of conditions during the past thirty years, which has made the majority of engineers employees of corporations, instead of private practitioners, and in some lines of work has led to the almost complete disappearance of the consulting engineer. It now seems that in future the greatest opportunity of the engineer will lie in planning and administration within the ranks of organized industry, and not in individual practice.

The author has packed a surprising amount of information into the 86 pages of her report. The basic facts are well documented and have been ably analyzed; the conclusions are clearly stated. The brevity and completeness of the book are its best recommendations. It should be in the hands of everyone interested in the progress of engineers and engineering.

## Automatic Control of Colliery Tubs

In a colliery the greater the speed with which the coal can be brought to the surface and passed on to its destination, the greater will be the output, and when handling risks can be greatly reduced the benefits to be derived are incalculable, states the Edgar Allen News for December, edited and published by Edgar Allen and Company Limited, Sheffield, England.

There are many fundamental points of similarity between the working of a railway and the working of a colliery. Each has to deal with the moving of large masses of material, from point to point, over pre-determined routes, and to each, speed of operation with proper regard for safety is an important factor.

Their many years of practical experience in such problems in connection with railway operation enabled the Westinghouse Brake and Signal Company to develop systems and apparatus to handle satisfactorily such problems in colliery working.

# BRANCH NEWS

## Halifax Branch

*R. R. Murray, A.M.E.I.C., Secretary-Treasurer.*
*Chas. Scrymgeour, A.M.E.I.C., Branch News Editor.*

The first fall dinner meeting of the Halifax Branch of The Engineering Institute of Canada was held in the St. Julian room of the Halifax hotel, Thursday, November 19th, 1936, there being about twenty-five members present.

The speaker for the evening was Professor G. Vibert Douglas, Professor of Geology of Dalhousie College, who presented a paper based on his experience in metal mining in various parts of the world which included Africa, Belgian Congo, Northern Rhodesia, Europia and Canada. Professor Douglas also had a large number of unusually interesting slides showing the various formations found in the development of these mines, as well as slides of photographs of the mines, his address being particularly interesting and providing for considerable discussion at the end of the address.

Prior to the talk given by Professor Douglas, the chairman of the Halifax Branch of The Engineering Institute, C. S. Bennett, A.M.E.I.C., made reference to the recent loss the Halifax Branch had suffered through the death of Professor F. R. Faulkner M.E.I.C., and in his memory the members observed a two minutes silence. The chairman, in speaking of the deceased member, made particular reference to the work Professor Faulkner had done in the past for the Halifax Branch of The Engineering Institute and said that the Branch had suffered a deep loss of a valuable member.

## Hamilton Branch

*A. R. Hannaford, A.M.E.I.C., Secretary-Treasurer.*
*A. B. Dove, Jr.E.I.C., Branch News Editor.*

"Heat Insulation Tests and Their Value" was the subject of a lecture delivered by Professor E. A. Allcut, M.E.I.C., of Toronto University, to the Hamilton Branch on Tuesday, November 17th, 1936.

The lecturer explained how he had been asked to investigate this subject by the Tariff Advisory Board who were confronted by the importation of insulation which was not standardized in any way. These materials had with them test sheets which actually meant very little, and the Professor was set the task of showing what was necessary in order to make a test sheet of any real value for purposes of comparison.

Professor Allcut described, with the use of slides, the apparatus used in Toronto University to test samples of insulation, both by the simple hot plate method and the hot box method. The conductance is the amount of heat which will pass through 1 square foot of sample in one hour when there is a temperature difference of one degree and is the unit in use during the tests.

A number of slides were shown giving graphical results of a number of tests. In these, the conductivity, which is relative to the conductance, was plotted and attention was directed to the fact that conductivity varied with different thicknesses of specimen, with different mean temperatures, and with variation in the moisture content of the specimen.

The speaker explained that a film of air on each surface of the specimen had to be considered an insulator, and when the thickness of the specimen varied, the proportion of air film to specimen changed, affecting conductivity values. With regard to moisture content, it was shown from actual tests how the conductivity varied with different percentages of moisture.

In selecting an insulator, the buyer must consider first cost, cost of applying and depreciation. Comparable test conditions must obtain to give one a true value of the material. The buyer should also consider the fire resistance and also vermin resistance of the substance.

Quoting from statistics of the Dominion Fuel Board it was estimated that if all the homes in Canada were properly insulated the saving in a year to the country would be in the neighbourhood of thirty million dollars, while the saving in the four cities Montreal, Toronto, Ottawa and Hamilton would be seven millions.

Interesting figures were given as to heat losses from tests made in two hundred homes. The distribution of the heat loss was

| | |
|---|---|
| Roof | 16.2 per cent |
| Walls | 27. per cent |
| Glass | 25.8 per cent |
| Infiltration | 24.6 per cent |
| Doors | 4.3 per cent |
| Other | 2.1 per cent |

and it was estimated that by the use of insulation, weather stripping and storm sash this could be reduced by 13 to 35 per cent.

W. Hollingworth, M.E.I.C., chairman of the Branch, who occupied the chair for the evening, conveyed to the lecturer the hearty thanks of those present.

At the outset of the meeting, Mr Hollingworth welcomed to the meeting the Hamilton Chapter, Ontario Association of Architects, who were headed by Mr. W. J. Holcombe, who is this year the local President. Mr. Holcombe expressed the thanks of the architects and assured the speaker of the evening that the subject was one which was of great importance to architects.

The meeting adjourned at 9.45 and thereafter refreshments were enjoyed. The attendance was seventy-five.

On Tuesday, December 8th, 1936, the Hamilton Branch of The Engineering Institute met at Hamilton Hall, McMaster University, with W. Hollingworth, M.E.I.C., in the chair. The speaker of the evening, D. G. Geiger, A.M.E.I.C., transmission engineer with the Bell Telephone Company of Canada, Toronto, was ably introduced by J. T. Thwaites, Jr.E.I.C.

### Speech and Music

Mr. Geiger opened his address by an explanation of that elusive and somewhat misunderstood relative power term, the "db." or decibel; this is a measure of gain or loss of amplification and is mathematically referred to as the product of the natural logarithm of the db. multiplied by .006, the reference wattage. Thus a power ratio of 10 is a gain, or plus 10 db.

The speaker discussed those factors important to the transmission engineer and to the telephone subscriber or radio listener. Intelligibility must be preserved, he said, by a knowledge of:

(*a*) The physical nature of speech and music.
(*b*) The reaction of the transmission.

The speaker explained that certain sounds are originated at the larynx, while others depend upon the tongue and roof of the mouth alone. The roof of the mouth and nasal cavity act somewhat as an amplifying chamber, amplifying the throat sounds.

In an explanation of musical notes, Mr. Geiger showed that music has its basis in two classes of instrument, namely vibrating strings or air columns. The fundamental note, he showed by comparative slides of various instruments, usually, but not always, has the lowest frequency present. The pipe organ is one exception to this. Timbre or quality is given by the relative amplitudes of the overtones present. The violin gives the purest tone, and has the simplest wave form largely due to the fact that it exists in almost a single frequency This adds much to the enjoyment of the instrument.

In an extensive study of overtones and frequency permissible in radio reception, it was found that little was lost in filtering out the frequencies below 35 and above 8,500 cycles. The newer types of receivers have this broad reception and naturally the tone of such instruments is much more pleasing than the type which cut out the upper or lower harmonics. Station WLW at Cincinnati is an example of up-to-date broadcasting equipment, and has a noticeable quality reception value over the Canadian stations.

Some frequencies are delayed over wire lines and equipment, delays of even 50 milliseconds are noticeable. Amplifiers and magnetic circuits, moreover, must not set up spurious frequencies. Mr. Geiger stated that one frequent difficulty met in transmission engineering was the possibility of cross talk from radio to telephone lines and vice versa. One did not object to music on the telephone, but the public apparently does not appreciate broadcast of its private conversations over a coast-to-coast hookup.

To persons suitably seated a symphonic orchestra frequently has a range of 10 to 70 db. At the amplification value of 10 db. little can be heard above the audience noise. Experiments conducted at Philadelphia with the Philadelphia Philharmonic Orchestra showed perfect reception in Washington by multispeaker arrangements; so natural was the reproduction that the Washington audience believed the orchestra to be in Washington.

Mr. Geiger then, by means of recordings and amplification apparatus, showed experimentally the effect of cutting out frequencies above and below natural C (256 cycles). These experiments included voice, an instrumental trio—piano, French horn and violin—and orchestral arrangements. It was particularly noticeable that, when playing their natural notes, without overtones, the three instruments of the trio could not be distinguished one from the other. This experiment proved the timbre or quality to be due entirely to the presence of the upper harmonics, without appreciable change in volume. The elimination of the lower frequencies detracted from the volume. Mr. Geiger completed his experiments by showing a comparison of orchestral music on the older phonograph records and the new V.E. (Victor Electro) type, and experiments demonstrating delayed frequencies, distortion, acoustic reflection, and overloading of amplifier systems.

At the close of Mr. Geiger's talk, a vote of thanks was moved by D. W. Callander, A.M.E.I.C., of the Canadian Westinghouse Company. Refreshments were served on adjournment.

## Lakehead Branch

*G. R. McLennan, A.M.E.I.C., Secretary-Treasurer.*

The regular monthly dinner meeting of the Branch was held in the private dining room of the Prince Arthur hotel, Port Arthur, on November 18th, 1936. Seventeen members were present and the chairman, F. C. Graham, A.M.E.I.C., presided.

The meeting was held for the discussion of business and to give G. H. Burbidge, M.E.I.C., councillor, the opportunity of presenting his report of the plenary meeting which he attended last September. Considerable interest in the report was evident and it was suggested that Mr. Burbidge make a further report at a later date when more information in regard to the plenary meeting is in the hands of the members. A vote of thanks to the speaker was moved by J. M. Fleming, A.M.E.I.C., and seconded by B. A. Culpeper, A.M.E.I.C.

A resolution in regard to the status of the engineer was passed and the secretary was instructed to forward the resolution to the secretary of The Institute.

Mr. Burbidge extended an invitation to all university graduates to attend the dinner on the 27th of this month to be given under the auspices of McGill graduates of the Lakehead in honour of Mr. Stephen Leacock.

## Lethbridge Branch

*E. A. Lawrence, S.E.I.C., Secretary-Treasurer.*
*R. F. P. Bowman, A.M.E.I.C., Branch News Editor.*

On the afternoon of Saturday, October 17th, 1936, members of The Institute and friends inspected the surface plant of the new Galt Mine No. 8, of the Lethbridge Collieries, Ltd. The party viewed with interest the modern tipple equipment, and the new electrical hoisting machinery. The boiler plant, workshops and other lesser buildings incidental to a coal mine were visited and explained by mine officials.

In the evening the regular dinner meeting was held at the Marquis hotel. After the usual musical programme the speakers for the evening, two in number, were introduced by J. B. de Hart, M.E.I.C. The first speaker was Wm. Meldrum, A.M.E.I.C., engineer for the Lethbridge Collieries. The guest speaker was Mr. E. J. Carlyle, of Montreal, present General Secretary of the Canadian Institute of Mining and Metallurgy.

### The Galt Mines' Fourth Venture

In introducing the subject, Mr. Meldrum dealt briefly with the economic limitations on the life of a coal mine. From experience, one might estimate the total output for the new No. 8 Galt Mine to be 5 million tons of coal, beyond which the cost of such factors as long main entries, ventilation, haulage, etc., becomes prohibitive. Based on the approximation of 4,000 tons per acre, the workable area is then limited to about 5,000 feet in radius.

The history of the Galt interests in this field began in 1883, and by 1935, the year of closing Galt Mine No. 6, 10,648,000 tons of coal had been produced. Erection of the new mine began in 1934, and the aim is 1,000 tons of coal per day.

The hoisting and air shafts are each 354 feet deep, and from these the main entries radiate in a coal seam 4 feet 10 inches in thickness. The system of underground workings, and also the modern electrical coal cutters were dealt with at length by the speaker.

### One Troy Ounce of Gold

"Civilization follows the miner," to quote Mr. Carlyle, and in Canada this fact is doubly true. The perseverance of the miner has lifted the barrier and pushed civilization back into Canada's wooded northland. In January, 1934, the price of gold sky-rocketed to $35.00 per ounce, thus adding great stimulus to gold mining activity. Canada's share of the world's gold last year was 11 per cent, valued at $100,000,000.

The "Troy Ounce," originating in France, was adopted into England by Edward III for weighing precious stones and jewels. It runs about 10 per cent heavier than the customarily used avoirdupois ounce.

By a number of interesting comparisons, Mr. Carlyle stressed the fact that gold occurs in ores in extremely minute quantities, and winning the precious metal from the gangue material is the problem of "finding a needle in a haystack."

Chemical analyses and microscopic examination are the tools of the successful ore-dresser in extracting the gold, because they show him how the gold is associated with the other minerals. The operation of cyanide extraction of gold was discussed by the speaker, who explained that this is the predominant method used in Canada today.

A simple sketch enlightened the listeners on the underground layout of a typical gold mine, serving to familiarize them with the mining terms used.

Following the talk proper, Mr. Carlyle, upon request, delighted the gathering with a few interesting and humorous reminiscences of his world-wide travels and experiences.

On Saturday, November 21st, 1936, the members of the Lethbridge Branch of The Engineering Institute of Canada with their wives and friends paid a visit to the recently completed beet sugar refinery of the Canadian Sugar Factories Ltd., at Picture Butte. Approximately ninety were in the party, and during the afternoon they were shown through the plant by the members of the technical staff of the company. Following this a dinner was served in the company's dining hall. Community singing and solos were enjoyed.

### The Manufacture of Beet Sugar

Mr. F. H. Ballou, chief engineer of Canadian Sugar Factories Limited, gave an address, in which he gave an historical outline of the beet sugar industry, which had its origin in Germany about 1747, but it was fifty years before a practical process for commercial production of sugar from beets was developed. Napoleon Bonaparte encouraged the industry with the result that by 1812 there were forty factories in France.

In the process followed on this continent the raw beets are brought from the farms and either stored in large piles or delivered directly to the wet hoppers and carried by water to the trash house where sand, leaves, rock, etc., are removed. A large beet wheel raises the beets from the flume, draining off the flume water and discharging them into the beet washer where they are agitated in clean water and passed to the roller table where further dirt is removed. The clean beets are then elevated to the beet hopper being hand picked for rotten beets and are passed over a magnetic pulley. Next the beets go to the slicers and are cut into shreds called cosettes and discharged onto a conveyer belt on which they pass over a weightometer and thence to the diffusion battery, a series of 14 upright cylinders each with a capacity of 4 tons of cosettes, where hot water at 55 degrees Centigrade is circulated to remove the sugar from the beets by osmotic action. The juice thus removed is treated with a milk of lime and carbonic acid gas, which precipitates some of the non-sugars. The juice is then given another carbonation of an alkalinity differing from the first treatment, resulting in the precipitation of more non-sugars, leaving a juice which contains about 17 per cent sugar; which is then treated with sulphur dioxide, neutralizing the alkalinity and having a bleaching action.

The juice next goes to the evaporators where the water content is reduced in a series of tanks operating under varying pressure conditions. Melted sugar is added to the thickened juice and the sulphur treatment repeated, followed by another filtration, after which the juice is boiled under reduced pressure and the first crystalization takes place, the crystals being separated from the mother liquor in high speed centrifugal machines. The mother liquor is twice treated and further sugar extracted till finally only a molasses is left which is used either as a cattle feed or is treated further at the Raymond plant of the company and still more sugar extracted.

The sugar from the centrifugals is dried and elevated to the top of the packing house where it is bagged or is passed to the bulk storage bin.

The average season for a plant of the type at Picture Butte is a seventy-five-day run during which about 100,000 tons of beets are handled and about 298,000 100-pound bags of sugar produced. A staff of two hundred and forty-six is required in and about the factory during the run.

The meeting also heard from Mr. Geo. Wood, district manager of the sugar company, and Mayor D. H. Elton of Lethbridge. A hearty vote of thanks to the speaker and the Sugar Company was proposed by C. S. Donaldson, A.M.E.I.C., and heartily endorsed by those present.

The Lethbridge Branch of The Engineering Institute of Canada met in the Marquis hotel on Saturday evening at a special Ladies night. Major Cross was the speaker. A musical programme followed the dinner, to which solos were contributed by Mrs. Wm. Meldrum and Geo. Brown, Jr. Community singing was also enjoyed.

The speaker of the evening was introduced by G. S. Brown, A.M.E.I.C. He is superintendent on the Eastern irrigation project at Lethbridge, and designed the War Memorial for The Institute now in headquarters.

Major Cross said that in Canada we live in a new country and so are builders. And to build well we must build on the knowledge of past accomplishment, the accomplishments of other peoples and civilizations. For example, the work of the Romans in Britain.

The Romans exhibited wonderful engineering in their works, for example the hot air ducts in the baths are perfect, and the tile of which they are constructed is better than that generally made today. Many of these old arts and crafts are lost.

Major Cross was much impressed, during a recent visit to England, by the railways, which although moderate in price, were both fast and comfortable. He was also impressed by the great port of Manchester, and by the display of naval power at the review of the navy by the late King. Recent industrial developments were large, and there is a great boom in home and apartment building.

The speaker showed a film which illustrated how beauty was related to line, colour, and light and shade, its development and uses, and showed its application in modern industry.

A vote of thanks was moved to the speaker by Mr. F. A. Rudd, after which the members adjourned to the mezzanine for bridge.

## London Branch

*D. S. Scrymgeour, A.M.E.I.C., Secretary-Treasurer.*
*Jno. R. Rostron, A.M.E.I.C., Branch News Editor.*

The regular monthly meeting of the Branch was held on October 20th, 1936, in the City Hall auditorium. Jas. Ferguson, A.M.E.I.C., chairman of the Branch, presided.

The speaker of the evening was Mr. W. O. LeBere of the Canadian National Railways, who is engaged in accident prevention work.

After the reading of the minutes by the secretary, the chairman introduced the speaker.

### Safety in the Erection of Steel

Attention was called to the necessity of the foreman keeping an eye on the condition of his men when reporting for duty. The plan recommended by the speaker, and which he adopts, is to address the men before they start and call their attention to the necessity of care and caution in their work not only for their own safety but that of their fellow-workers. This has the effect of making the men appreciate the effort to safeguard them and stimulates in them a desire to co-operate.

The next point stressed was the necessity of thoroughly overhauling and testing all equipment before use in the field, particularly with regard to cable used in hoisting. In the case of handling heavier loads than usual or in the use of special equipment, the method of operation should be first discussed with the foreman and the strength of the equipment worked out from the engineering angle and not left entirely to the foreman's judgment in the field.

Two prolific sources of accident were named, one being improper and insufficient plank gangways in buildings and hanging scaffolds for riveting both in building and bridge work. Regarding the latter the speaker favoured what is called the ship scaffold, consisting of a plank deck 4 or 5 feet wide and 6 or 8 feet long hung by manilla rope at each corner, as against slinging pipes or beams with loose planks laid on them.

Accidents will happen, and before starting a job of any size full consideration should be given by the contractors and engineers as to what to do when they occur. A first-aid station should be established with a competent man in charge, a survey of the district made and the best doctor for accident work selected and also the nearest suitable hospital. Then, having decided these matters, definite instructions should be given to the foreman and men as to how to act in a case of emergency. Not only were these precautions necessary from a humanitarian point of view, but also from an economic standpoint, in preventing excessive loss from compensation, etc.

The speaker concluded his remarks by making a prophecy of the measures that would be taken during the next fifty years in promoting accident prevention, and the reasons for it.

An interesting discussion followed the speaker's talk and the meeting adjourned after a vote of thanks was proposed by J. R. Rostron, seconded by H. A. McKay, A.M.E.I.C., and unanimously carried.

The regular monthly meeting of the Branch was held on November 25th, 1936, in the board room of the Public Utilities Commission in the city hall.

After the reading of the minutes, the speaker of the evening, J. A. Vance, A.M.E.I.C., was introduced by the chairman, James Ferguson, A.M.E.I.C., who pointed out that Mr. Vance's subject was "Consolidation of the E.I.C. and the Provincial Associations of Professional Engineers" and that as Branch Councillor, Mr. Vance would be able to tell the members of the proceedings up to date on this subject.

Mr. Vance opened by giving a short description of events leading up to the formation of the Dominion Council with C. C. Kirby, M.E.I.C., of New Brunswick, as chairman, and A. B. Crealock, M.E.I.C., of Toronto, as vice-chairman.

He enumerated some of the recommendations of this Committee and went on to the discussion of Council on these matters at its meeting on September 18th, 1936. The most contentious recommendation was that of Section 7 (*b*) which stipulates that in a province whose association becomes Component, a prospective member must be a member of the association before he can be admitted to corporate membership in The Engineering Institute.

The speaker pointed out that the present members of each body would not be affected by this ruling except that all association members would be admitted to The Institute upon application duly made. He read extracts from the minutes referring to this and also copies of correspondence from various engineers both agreeing and disagreeing.

Mr. Vance then took up the question of fees, and stated that it was proposed to abolish the class of Associate Member of The Institute, all present Associate Members becoming Members, and to fix the annual fee for Members at $1.00 more than is now paid by Associate Members. This increase is necessary in order to meet the loss incurred by what would otherwise be a $2.00 reduction of Members' fees.

It was felt by many present that this would mean a loss of new membership to The Institute, for undoubtedly a large number after gaining admission to the Association would not go any further.

Mr. Vance stated the position of affairs exhaustively and quite impartially for the benefit of members present.

A long discussion followed the speaker's remarks; many opinions were expressed but no resolution was passed.

After a hearty vote of thanks to the speaker the meeting adjourned.

## Montreal Branch

### Observations on European Railroad Motive Power

On November 26th, 1936, Mr. A. I. Lipetz, chief consulting engineer in charge of research for the American Locomotive Company, presented a paper before the Montreal Branch of The Institute, describing his European experiences with the Moscow-Kiev-Voronesh Railway. Mr. Lipetz outlined recent European and American railway developments, his address being illustrated with a number of excellent slides.

Previous to the meeting an informal dinner was held at the Windsor hotel, and a special general meeting of the Branch was convened to elect three members on the Branch Nominating Committee.

H. H. Vaughan, M.E.I.C., was in the chair.

### Junior Section

"Patents, their Value and How they are Obtained" was the title of the address given by Mr. Alan Swabey before the Junior Section of the Montreal Branch on November 30th, 1936.

Virgil S. Upton, S.E.I.C., also spoke on the "Design and Manufacture of Aircraft." Mr. Upton, who is chief stress analyst at the Noorduyn Aircraft Limited, St. Laurent, Que., described the steps taken from the time specifications are laid down until the aircraft is test flown. Motion pictures of test flights were shown.

P. E. Savage, S.E.I.C., acted as chairman.

### Recent Advances in Electric Welding

At the meeting of the Montreal Branch held on December 3rd, Mr. H. Thomasson, welding engineer with the Canadian Westinghouse Company, spoke on recent advances in electric welding, describing a newly developed process for arc welding, and on present trends in arc welding design. The paper was illustrated with slides and specimens. This paper appears in full in this issue of The Journal.

Prior to the meeting an informal dinner was held at the Windsor hotel.

D. C. Tennant, M.E.I.C., occupied the chair.

### Town Planning in Montreal

H. A. Terreault, M.E.I.C., addressed the Montreal Branch on December 10th, his talk including a 3-point plan for Greater Montreal under the headings of traffic congestion relief, zoning laws, and parks and playgrounds.

A number of members of the Province of Quebec Association of Architects were present at the meeting, following which light refreshments were served.

The chairman was Leonard Schlemm, M.E.I.C.

### Junior Section

"Steel Rails" was the subject of a talk by Hugh J. Gordon, S.E.I.C., at the meeting of the Junior Section of the Montreal Branch held on December 14th. The speaker reviewed such features as the history, problems arising from service, stresses, defects and their detection, and some of the more recent developments in steel rails.

The second speaker, V. F. Crowley, described the manufacture of high tension porcelain insulators, his talk being illustrated with motion pictures.

R. Warnock, S.E.I.C., acted as chairman.

## Ottawa Branch

*F. C. C. Lynch, A.M.E.I.C., Secretary-Treasurer.*

### Preservation Treatment of Structural Timbers

At a noon luncheon at the Chateau Laurier on November 5th, 1936, J. F. Harkom, B.Sc., A.M.E.I.C., of the Forest Products Laboratories of Canada, gave an address upon "Preservation Treatment of Structural Timbers."

E. Viens, M.E.I.C., chairman of the Ottawa Branch, presided and in addition head table guests included: Colonel A. E. Dubuc, M.E.I.C., Commander C. P. Edwards, A.M.E.I.C., R. L. Sargent, J. M. Wardle, M.E.I.C., F. H. Peters, M.E.I.C., R. A. Gibson, D. Roy Cameron, M.E.I.C., T. A. McElhanney, A.M.E.I.C., F. G. Smith A.M.E.I.C., and A. K. Hay, A.M.E.I.C.

Mr. Harkom gave the chief causes of deterioration or destruction of timber in service as weathering, insects, marine borers, fire and decay. After dealing rather briefly with the first four he dwelt at length upon the subject of decay and of methods of retarding it, particularly by the use of preservatives. These latter he divided into two classes: oils such as creosote or mixtures containing creosote, and water soluble salts such as zinc chloride.

He also described laboratory methods for the testing of preservatives and indicated the different treating schedules required to obtain best results with different Canadian woods. His complete address will be published in The Engineering Journal.

### The Stone of the Vimy Memorial

At a noon luncheon at the Chateau Laurier on November 19th, 1936, M. F. Goudge, Ottawa, gave an address to the Ottawa Branch on the stone used in the construction of the Vimy Memorial. Mr. Goudge, who is an engineer on the staff of the Department of Mines engaged in investigational work on building stone, marble, and limestone, was present at the unveiling of the Vimy Memorial during the past summer and subsequently obtained much interesting information on the quarrying of the stone and on the details of the construction of the Memorial. His address was illustrated with lantern slides. E. Viens, M.E.I.C., chairman of the Ottawa Branch, presided and in addition head table guests included: A. L. Watson, Col. A. F. Duguid, A.M.E.I.C., G. J. Desbarats, Hon.M.E.I.C., J. M. Wardle, M.E.I.C., F. C. C. Lynch, A.M.E.I.C., John McLeish, M.E.I.C., A. F. Macdonald, P. Sherrin, A.M.E.I.C., B. H. Segre, A.M.E.I.C., Group Captain E. W. Stedman, M.E.I.C., and C. M. Pitts, A.M.E.I.C.

The stone is a beautiful cream colour quite unlike the limestones usually seen in this country. It shows up very plainly in the daylight and when floodlighted at night the Memorial can be seen for miles. It came from a quarry in Dalmatia which had been last used by the Romans under Diocletian in 305 A.D.

The clearing of the site for the Memorial itself was quite an arduous undertaking and the basement was built on a concrete raft two feet thick resting on chalk.

The stone was cut to order at the quarry and each stone was numbered to occupy a certain place in the finished memorial.

Several other large memorials are located in France and Belgium, stated Mr. Goudge, but in his opinion the Vimy Memorial was the finest of them all. In it there was no trace of vindictiveness or of the conquering spirit, but rather of the sadness, sacrifice, and utter futility of war.

Methods of quarrying the stone and engineering problems that had to be met in the construction of the memorial were detailed by the speaker with the aid of the pictures.

#### Changing Over to the Dial System

F. D. Laurie, local manager of the Bell Telephone Company, gave a talk at the noon luncheon at the Chateau Laurier on December 3rd, on "Changing over to the Dial System." He also presented motion pictures illustrative of the recent advances made in trans-oceanic telephony.

The introduction of the dial system in Ottawa, he stated, would be of an evolutionary rather than a revolutionary nature and no hardship would result to the operating staff. The first changes would be made late in 1937 and others would follow until the entire change was made.

He paid tribute to the wonderful work of the scientists and engineers and their dogged persistence in overcoming the many difficult problems met with to perfect a system which so well meets the business and social demands of the day. Since its early days of sixty years ago improvement has been effected to every feature of telephonic communication; lines, switchboard, apparatus; and in this improvement scientific research has played a major part.

With the motion pictures the types of apparatus used on shore and on shipboard to maintain telephonic communication were illustrated. As an indication of advances that have been made the speaker stated that on a recent round the world cruise experimental telephonic communication had been established to New York City from points half-way across the Pacific, from the Indian Ocean and from the Red Sea.

E. Viens, M.E.I.C., chairman of the local Branch, presided and additional head table guests included: Hon. C. D. Howe, M.E.I.C., Mayor Stanley Lewis, Commander C. P. Edwards, A.M.E.I.C., A. H. Fitzsimmons, R. F. Howard, M.E.I.C., John McLeish, M.E.I.C., J. M. Wardle, M.E.I.C., Dr. S. F. Kirkpatrick, T. L. Simmons, M.E.I.C., J. E. St. Laurent, M.E.I.C., Group Captain E. W. Stedman, M.E.I.C., J. G. Macphail, M.E.I.C., V. M. Meek M.E.I.C., and John Murphy, M.E.I.C.

## Peterborough Branch

*W. T. Fanjoy, A.M.E.I.C., Secretary-Treasurer.*
*E. J. Davies, A.M.E.I.C., Branch News Editor.*

#### Annual Dinner

The annual dinner of this Branch was held on Tuesday, November 17th, 1936, at the Empress hotel, with a good attendance of members and guests. H. R. Sills, A.M.E.I.C., Branch chairman, presided. A message from the President was read and responded to by Vice-President R. L. Dobbin, M.E.I.C. A feature of this dinner was a presentation, in absentia, to Mr. B. L. Barnes of an Honorary Affiliated Membership in this Branch in recognition of many years of valuable service to the E.I.C.

The speaker of the evening was Mr. Desmond Killikelly, assistant to the vice-president, Steel Company of Canada, Montreal, who spoke on the subject, "Canada in the Midst of the World's Political Unrest." Mr. Killikelly gave a very vivid and different viewpoint of this question to the gathering. He warned that the issues facing the world to-day are a direct challenge to democracy wherever it exists, and are a threat to the safety of civilization and of Christianity itself.

Pointing out Canada's part in the scheme of current affairs and the responsibility of Canadians as individuals, the speaker declared he was a firm believer in a militant democracy, even as he is a believer in a militant Christianity.

He stated there is no war which threatens the peace of the world in which Canada has no direct concern, all talk of pacifism or neutrality to the contrary.

The speaker described "unity of all the peoples of Canada" as one of the great needs because there are already too many unhealthy symptoms of unrest and dissatisfaction with the status quo.

Mr. Killikelly said, "We should ever be on the alert, ever watchful, ever ready to lend a sympathetic ear, and to try and understand the other fellow's grievances, problems or point of view. Otherwise we fertilize by indifference, neglect or prejudice the soil in which Fascism, Bolshevism or Anarchy flourish.

"We have a heritage to guard. Is it worth saving? Is our civilization a worthy patrimony to leave our children? Let us turn back to God and the humanities of life in a united effort to save our achievements from the plague which threatens; keep our minds free from the prejudices of race, language or religion, and unsoiled by falsehoods one towards the other. This is not a mere hour of politics which attracts our attention—it is an hour of national importance."

#### Concrete Highways

The regular monthly meeting was held on December 10th, at which the speaker was D. O. Robinson, A.M.E.I.C., publicity engineer, Canada Cement Company, Toronto.

Mr. Robinson gave a very interesting and thorough discourse on this subject, in which he emphasized the fact that the main consideration in the construction of concrete highways was a satisfactory, permanent and lasting surface, as this was the greatest factor which would induce the construction of further roads.

Mr. Robinson took as an example the construction of a concrete road to replace a first class gravel road and led his hearers through all the steps from resurveying of the existing road to check for grades and curves, through the location, selection, grading and washing of materials, to the actual laying and finishing of the road. He mentioned in detail the many steps involved both by the contractor and the Department of Highway Engineers to check and test in order to be assured that the finished road was uniform throughout.

## Saskatchewan Branch

*J. J. White, M.E.I.C., Secretary-Treasurer.*

The Papers and Library Committee of the Saskatchewan Branch of The Engineering Institute arranged a summer meeting in the nature of a trip to the Fort Peck dam near Glasgow, Montana, U.S.A. The trip was well organized by R. W. Allen, M.E.I.C., of Regina. Starting from Regina on September 18th, 1936, the party travelled by motor to Glasgow, spending all the day of September 19th at the dam and returning on September 20th.

At Fort Peck the party of twenty-five members of the Branch and their friends were the guests of the United States War Department, which Department had full charge of the construction work under the supervision of the Divisional Engineer, Missouri River District, Kansas City, Mo.

Looking after the pleasure and instruction of the party at the dam was Paul A. Harper. Mr. Harper arranged parties to visit the points of interest, these parties being supervised by competent guides capable of discussing the various phases of construction which were many on work of such magnitude.

The primary engineering purpose of the Fort Peck dam on the Missouri river is the improvement of navigation in the new 8- to 9-foot channel below Sioux City, Iowa, with incidental purposes of flood control and the prevention of bank erosion.

In addition to the strictly engineering purposes, the dam is being constructed at this time to provide work for the unemployed. Employment on July 15th, 1936, was 10,546.

The maximum height of the dam will be 242 feet above the river bed; the length of the main section across the river valley will be about 9,000 feet. The reservoir created by the dam will store 19,412,000 acre-feet of water, and will have a maximum surface area of 245,000 acres.

Four diversion tunnels to carry the Missouri river around the dam and also to control the release of water from the reservoir are being constructed under the right (east) bank. Work commenced on the tunnels in May, 1934. Each will have a finished inside diameter of 24 feet 8 inches, and will vary in length from 7,261 to 5,386 feet.

A flood spillway is being constructed on the east side of the river, approximately three miles from the dam by airline, and is designed to discharge a maximum of 255,000 cubic feet of water per second.

Stripping of overburden from the base of the dam, involving excavation of 4,153,530 cubic yards, was carried on during the summer and fall of 1934.

Construction has been completed on a cut-off wall of steel sheet piling along the axis of the dam. The piling was driven to a maximum depth of 163 feet below the surface to the underlying shale bedrock and extends approximately 20 feet above the original ground surface into the core of the dam. The wall is 10,146 feet long and contains 34,000,000 pounds of steel.

The dam is being constructed of earth by the hydraulic-fill method using four 28-inch, 12,500 h.p. electrically-operated dredge units which were built at the site by the government. On October 13th, 1934, one dredge commenced digging, and up to August 1st, 1936, a grand total of 35,063,250 cubic yards, or over one-third of the total amount required, had been placed.

In order to move the vast quantity of construction materials required for building the various features of the project, a railroad 12.2 miles in length, running from Wiota on the main line of the Great Northern, to the dam, was completed in April, 1934. It is estimated that 12,000,000 tons of material will be transported over this line.

Because of the inaccessibility of the damsite and the sparse population, it was necessary to construct a town, complete in all details, to house the workers on this large project. All heating is by gas, for which purpose an 8-inch line has been constructed from Glasgow to Fort Peck. A 154,000-volt, 50,000-kw. power line, 286 miles in length from Rainbow Falls to the damsite, was completed in September 1934. This line furnishes power for the dredges and all other construction purposes and for business and domestic use in the town of Fort Peck.

At the present time nothing is foreseen which will prevent the orderly completion of the project by the fall of 1939.

The proposed October meeting of the Saskatchewan Branch of The Institute was cancelled in order to join forces in a meeting with the Association of Professional Engineers of Saskatchewan. A number of Institute members were present at the dinner meeting which was preceded by attendance at the final game of Regina vs. Winnipeg in the Western Canadian Rugby Conference.

Some Modern Highway Tunnels and Long Span Bridges

The November meeting of The Institute was held on November 20th at the Champlain hotel, Regina, with thirty members in attendance. This was a dinner meeting, and the guest speaker was Professor R. A. Spencer, A.M.E.I.C., of the faculty of engineering, University of Saskatchewan, Saskatoon. Stewart Young, M.E.I.C., acted as chairman of the meeting.

During the business session R. W. Allen, M.E.I.C., chairman of the Papers and Library Committee, suggested that the Branch hold a meeting of the Kipling Camp at some convenient time during the winter months. Subsequently arrangements were made to hold this Camp, Mr. Allen acting with the Saskatchewan Secretary of the Camp, J. W. D. Farrell.

Mr. Young introduced Professor Spencer, whose topic was "Some Modern Highway Tunnels and Long Span Bridges." The speaker first pointed out that, if it is arbitrarily assumed that a long span bridge of to-day is one of a clear span of 1,000 feet or over, there is only one example in Great Britain, one in continental Europe, one in Australia, two wholly in Canada, and that all the others are in the United States. He then went on to show that the problem of the long crossing for highway traffic really began in about 1914, when there was a sudden upturn in the registration of motor vehicles. In that year, as an example, registration was two millions in the United States and there was a steady increase to over twenty-six millions in the year 1929. The problem began to be acute in certain sections in about the year 1920.

The construction of the Holland tunnels and the George Washington bridge was reviewed in some detail as examples that had far-reaching influence. Further late bridge and tunnel construction work in the New York area was then shown by means of slides. This was followed by brief comments on a number of late similar developments in other parts of the world.

In closing, the speaker compared the relative advantages and disadvantages of bridges and tunnels as regards construction and operating costs, traffic capacity, ease of access, etc. About one hundred and twenty-five lantern slides were shown to illustrate various features of the address.

The paper was followed by much interesting discussion and a hearty vote of thanks was moved by A. P. Linton, M.E.I.C.

## Sault Ste. Marie Branch

*N. C. Cowie, Jr.E.I.C., Secretary-Treasurer.*

The Sault Ste. Marie Branch of the Engineering Institute of Canada held a general meeting for members and guests at the Windsor hotel, Sault Ste. Marie, Ont. on November 30th, 1936.

Dinner was served at 7.00 p.m. to twenty members and guests in the hotel grill room.

Wm. Seymour, M.E.I.C., vice-chairman of the Branch, presided at the meeting, which commenced at 8.00 p.m. A few items of business were speedily attended to. The chairman then introduced O. A. Evans, Jr.E.I.C., of the Algoma Central Railway Mines Department, who spoke on "Gold."

Mr. Evans covered this timely subject in a general way, confining himself, as he stated in his introduction to a short synopsis of the properties, production, distribution and other interesting features of gold.

Mr. Evans' paper was well received by the meeting and was followed by a lively and interesting discussion by the members.

F. Smallwood, M.E.I.C., seconded by C. Stenbol, M.E.I.C., conveyed to Mr. Evans the appreciation of the meeting for his interesting paper.

## Vancouver Branch

*T. V. Berry, A.M.E.I.C., Secretary-Treasurer.*

Annual Meeting

The annual meeting of the Vancouver Branch was held at the Hotel Georgia on the evening of November 23rd, 1936. Thirty-eight sat down to dinner. At the head table with the Branch chairman, James Robertson, M.E.I.C., sat chairman-elect H. N. McPherson, M.E.I.C., vice-chairman elect Colonel J. P. McKenzie, M.E.I.C., President E. A. Cleveland, M.E.I.C., Past President Geo. A. Walkem, M.E.I.C., and the guest speaker of the evening, Mr. Rowe Holland, chairman of the Vancouver Parks Board.

Immediately following dinner, the financial report of the Branch for the year 1936 was presented by the secretary-treasurer, and the election of officers for the year 1937 held.

Dr. Cleveland, President of The Institute, briefly addressed the meeting on the problem of the consolidation of the engineering profession in Canada. He discussed the various controversial points raised by the branches and the Professional Associations. He expressed the opinion that much progress had been made towards the common objective and urged that when the final recommendations of Council are placed before the individual members during 1937, that they examine these recommendations with an open mind and free from sectionalism and partizanship, that the best interests of the profession may be served in Canada.

The guest speaker of the evening, Mr. Rowe Holland, a prominent Vancouver barrister and chairman of the Vancouver Parks Board, was introduced by P. H. Buchan, M.E.I.C.

Mr. Holland gave an inspiring and thoughtful address on his conception of the part played by the scientist and the engineer in the march of civilization. He characterized his early impressions of the engineer as being a "hard fisted realist" but later thought and experience matured his conception of the engineer as a "dreamer whose dreams come true." Behind all planning, labour and effort on the part of the engineer there are years of vision and dreaming. The engineer is a pioneer of thought—one who rends aside the veil that separates our tomorrows from our todays. The speaker expressed his opinion that through the efforts of the scientist and the engineer, civilization will gradually advance until mankind will elevate, and as he termed it "become a race of angels."

Major W. G. Swan, M.E.I.C., tendered the thanks of the meeting to Mr. Holland for his interesting and thought-provoking address.

## Winnipeg Branch

*H. L. Briggs A.M.E.I.C., Secretary-Treasurer.*

Junior Engineers' Association Evening

As a preliminary to the presentation of two papers by members of the Junior Engineers' Association, on December 3rd, 1936, G. E. Cole, A.M.E.I.C., described a number of interesting and humorous experiences relating to his early mining career, in No. 3 of an "I Remember" series being carried out at each meeting of the Branch by the senior members.

Engineering Generalities

A. Sandilands, S.E.I.C., proceeded to discuss the ethics of the engineering profession, and the relation of an engineer to other engineers and to the public. The engineer has no right to think only in terms of the generation of which he is an individual. He must continually scrutinize himself and his outlook—if he does not find things as he would like them, then he should co-operate to secure the changes desired. Regarding remuneration, the real engineer will consider himself well paid when he is able to experience that inner satisfaction of a job well done.

Recent Improvements in Telephone Communication Equipment

T. A. Lindsay described the modern telephone hand-set of the cradle type, scientifically correct in many more respects than the type of instrument it replaces. He told of a highly efficient magnetic type telephone which has been developed which requires no batteries to operate. It can be used over 30 miles of standard cable or 200 miles of open wiring, the voice transmission being remarkably free from distortion and from frying noises. Another development is a static frequency converter, whereby 60-cycle power is converted to 20-cycle pulsations suitable for ringing purposes, by means of a static network except for a starting relay.

Those taking part in the discussion which followed included N. M. Hall, M.E.I.C., E. V. Caton, M.E.I.C., F. G. Goodspeed, M.E.I.C., F. W. Alexander, M.E.I.C., and A. J. Taunton, M.E.I.C. The vote of thanks to Mr. Cole, the Junior Engineers' Association, and to Mr. Sandilands and Mr. Lindsay was proposed by H. M. White, M.E.I.C.

Secession Movements in Canada

On November 19th, 1936, Professor R. O. Macfarlane, Ph.D., of the Department of History, University of Manitoba, presented to the Branch some thoughtful observations upon a number of separatist movements which are present in greater or lesser strength in all provinces in Canada to-day.

The main national east and west boundary is at right angles to the natural economic lines, which are north and south. Canadian Confederation is an economic and political compromise, involving the giving up of certain rights which are often quite real, for other benefits which may not be so apparent. Confederation came just after the American Civil War. It appeared to the framers of the British North America Act that in the United States constitution too much power had been given the individual states and too little to the federal government. The British North America Act represents their efforts, among other things, to build a strong enough central power to overcome the difficulties which had shown up in the American union.

Continuing with individual cases, Professor Macfarlane pointed out that Canadian protectionist policy had been hard on the Maritimes. Also, the other provinces had received immense tracts of Dominion lands in their boundary extensions, whereas the Maritimes had not. They have blamed Confederation for their difficulties. Quebec, the speaker said, has recently developed strong fascist tendencies. Ontario believes that she is paying the piper for the other provinces. The prairie provinces have developed strong localization tendencies. Alberta has isolated herself economically by means of a radical credit structure. British Columbia has strong interests relating her to the south. In judging Confederation, then we must remember that it is a compromise.

Those taking part in the discussion included J. H. Edgar, A.M.E.I.C., and J. W. Porter, M.E.I.C. A vote of thanks to the speaker moved by F. W. Alexander, M.E.I.C., was heartily supported.

Previous to the main paper, Major J. H. Edgar, A.M.E.I.C., presented some humorous excerpts from the book "History of Canadian Railways," of which he is a co-author. He drew attention to the marked effect of the railways upon effective Canadian Confederation and noted that the greater amount of railway construction had occurred since 1867, with a standard gauge. In contrast with this is the case of Australia, federated in 1901, at which time each of the five states had its own railway lines, each of a different gauge.

The chair was occupied by G. E. Cole, A.M.E.I.C.

## The Motorways of Germany

In view of the present road situation in this country, any information about road procedure and practice elsewhere is of value, and considerable interest is likely to be taken in the particulars relating to the new arterial motor roads in Germany which were given by Herr Schmoelder, in a lecture delivered at the College of Technology, Manchester, on Monday, November 16th. Herr Schmoelder, whose lecture was entitled "The Motorways of Germany," dealt first with the programme of construction, which was begun in 1934. It is proposed to construct six motorways, two running roughly from north to south, and the other four from east to west. The total length will be about 4,500 miles, and the rate of construction is expected to reach 650 miles a year; over 750 miles have already been completed. The motorways are designed solely for mechanical transport, and connections to the ordinary road system are made only at large towns.

In general, the roads are divided into two tracks, each 20 feet 6 inches wide, separated by 14-foot strips, with haunches 3 feet wide at the edges. These haunches are laid early, and are used as foundations for the rails carrying the construction plant. The thickness of the concrete slabs is 8 to 10 inches, with steel mesh reinforcement at 4 pounds to the square yard; a camber of 1½ per cent is given to the road surface. The normal cement content of the concrete is 528 pounds per cubic yard. In the earlier work, the concrete was laid in two courses, the upper being of better quality, but single-course construction with uniform concrete is now adopted. The transverse joints are spaced at intervals of 26 to 65 feet, according to the conditions; they are of the standard dowelpin type, with bituminous fillers. The concrete is laid on waterproof paper, and all the subsequent operations are performed by machines spanning the track and running on a rail on each side of it. Full width construction is the general rule. The aggregate and cement are proportioned by weight at a mixing plant, and conveyed to the work by skips drawn by a locomotive running on a temporary track beside the road. The mixer delivers into distributor buckets which deposit the concrete in position. This is followed by a finishing machine, which levels the surface, tamps and vibrates it. Hand finishing is rarely used. The freshly-deposited concrete is protected against the weather by canvas coverings until it has set, and is afterwards kept wet for three to four weeks by wet sand, canvas, etc. Tests are made on all the constituents of the concrete, on samples from the mixers, and on a 6-inch core from every half-mile of road. The surface finish of the road is checked by an irregularity detecting machine, which gives an autographic diagram. The maximum rate of progress attained has been 220 yards of 20-foot 6-inch roadway in an eight-hour day; the average rate is about 130 yards a day.

The elimination of level-crossings has necessitated a large number of bridges and subways. In general, the material used is reinforced concrete, but occasionally steel and masonry are employed. Considerable attention has been paid to aesthetic considerations. In this, and all other aspects of the design of the motorways, architects, landscape gardeners, and others have collaborated with the engineers, with apparently very satisfactory results. Parking and rest places are provided at suitable spots. The Inspector-General of the German road system has absolute power over the work. "As the highest German road officer, he has the last word in all questions of planning, lay-out and technical design, and his decision is final in cases of expropriation or exchange of ground if these procedures should become necessary. As a rule, however, land is acquired by normal purchase." The German Railway is the "holding company" of the Motorway Company. This arrangement was adopted to avoid competition and to take advantage of the railway's long experience in the organization of transport. One of the objects of the scheme was the relief of unemployment, and 35 per cent of the cost is accounted for by the saving on "doles"; a further 25 per cent to 30 per cent of the money invested in the scheme will return as revenue from additional rates and taxes. The remaining 35 per cent to 40 per cent is granted by the Reich by a special agreement between the Reichsbank and the German Railway. The total capital invested up till the end of August, 1936, was £54,000,000. Herr Schmoelder described in some detail the arrangements which are made to ensure the welfare of the workmen, numbering about 120,000, of whom 20,000 live in camps. The services for road users are organized no less thoroughly. Telephones at 1¼-mile intervals, filling stations, and a well-equipped breakdown service are provided. Figures were given to show that the motorways had caused a large reduction in the traffic on the ordinary state highways, though the total volume of motor traffic in the country had increased. Reference was also made to the inauguration of a 'bus service, designed on a speed schedule of 55 m.p.h. to 60 m.p.h.—*Engineering.*

## Association of Professional Engineers of B.C.

The seventeenth annual meeting of the Association of Professional Engineers of the Province of British Columbia was held in Vancouver on December 5th. Colonel H. F. G. Letson, the retiring president, officiated and detailed the negotiations on consolidation during the past year. After discussion the following resolution was submitted and adopted:—

> "That the earnest efforts of the British Columbia Council on consolidation during the last two years has caused the partial exclusion or neglect of the usual activities in B.C. and it is essential to return to these activities in the forthcoming year. And further that this meeting wishes the very best of success to The Engineering Institute of Canada and the sister Associations in their endeavour to form a truly national representative body. And further as the B.C. Association Council, to the best of its ability has put forward its ideas consistently, both in writing and by visits to Hamilton, Toronto and Montreal, that this meeting considers that any further practical effort at consolidation should be sympathetically considered by the incoming Council."

**A. Vilstrup**

As a result of the elections Mr. A. Vilstrup was elected president of the Association for the year 1937. Mr. C. V. Brennan was elected vice-president. The following councillors were elected: James Robertson, M.E.I.C., representing civil engineers; E. Redpath representing mechanical engineers; F. W. MacNeill representing electrical engineers; and A. M. Richmond representing mining engineers.

Colonel H. F. G. Letson becomes a member of the Council as immediate past-president and will represent the mechanical engineers.

The meeting ended with a banquet at which the Hon. Mr. G. S. Pearson, Minister of Mines, Minister of Labour and Commissioner of Fisheries, was the guest of honour and speaker.

In his view, as regards the nature of the work to be done, British Columbia was a paradise for the engineering profession, but he intimated that the financial prospect was perhaps not quite so attractive.

One of the highlights of the evening was the introduction of all the past presidents of the Association presently living in Vancouver, as follows: Professor E. G. Matheson (Provisional president); D. O. Lewis, M.E.I.C.; W. G. Swan, M.E.I.C.; A. E. Foreman, M.E.I.C.; G. A. Walkem, M.E.I.C.; F. Sawford; A. S. Wootton, M.E.I.C.; W. R. Bonnycastle, M.E.I.C.; Major J. C. MacDonald, M.E.I.C.; A. S. Gentles, M.E.I.C.; J. D. Galloway and G. S. Eldridge.

The new president of the Association, Mr. A. Vilstrup, received his early education in Copenhagen, where he graduated in 1902. After some years in England he came to Canada in 1911, entering the service of the B.C. Electric Railway Company. He served successively as assistant engineer and assistant plant manager in the electrical department of the company, of which he is now chief electrical engineer. After serving as a member of the Council of the Association he became vice-president in 1936.

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*Canadian Wood Pipe and Tanks Ltd.* have been awarded a contract for the largest penstock of its kind ever built. It will be an important unit in the new $8,500,000 development for the Ontario Paper Company on the St. Lawrence river 250 miles below Quebec City. The penstock will measure 18 feet 3½ inches outside diameter and 6,000 feet in length and is for carrying water to their new 75,000 h.p. generating station at Outarde Falls. The electric power will be used in the paper mill at Baie Comeau. In addition to the penstock, the company will supply and erect the 24-inch water supply main and the wood stave flume, four miles in length, to be used as a water and wood conveyor. The material bill for these installations includes 2,500,000 feet b.m. of B.C. Clear fir; 5,000,000 pounds of steel for cradles and bands, and 200,000 pounds of malleable iron fittings.

## The Social Responsibilities of the Engineer

**Extracts from a paper by J. K. Finch, Renwick Professor of Civil Engineering, Columbia University, New York, appearing in the December, 1936, issue of "Civil Engineering."**

The idea has frequently been expressed that engineering activity has made this an engineering age, that it is the engineer who is responsible for the many perplexing economic and social problems we now face, and therefore, *ipso facto,* it is up to the engineer to solve them. Discussion and protest along these lines will probably continue for many years, although a common-sense consideration of the problem will show that the engineer is not responsible for many of the major difficulties of the situation; that it is, in fact, a general problem of Western civilization; and that engineering, powerful and constructive as it is, possesses no magical key which will unlock the gates to a rosy and peaceful future.

* * * *

The public has been led to believe that we are on the verge of a new era in which, in some mysterious way, the engineer can annihilate costs and provide almost free service for all—only "a lack of vision and flexible technical capacity" on the part of the engineering profession holds up the march into Utopia. The abilities of the profession are thus questioned, and the atmosphere should be cleared if sound progress is to be made.

Throughout the ages, the engineer's principal stock-in-trade has been his reputation for absolute honesty and meticulous care in searching out, analyzing, and appraising the basic facts and economic values of those enterprises in the field of his professional activities. When he has recommended a work, he has staked his reputation and standing on its feasibility and soundness. Almost without exception, engineers damned the Passamaquoddy and Florida projects, but no attention was paid to their statements. Similarly, the white elephant at Fort Peck was begun before any economic study worthy of the name had been made, and the engineers were then called in to say that what had been done was wise and good.

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A bridge may fail physically, through errors in structural design or judgment, or it may fail economically through similar errors of economic analysis or judgment. Either failure is an engineering disaster. There are, thus, many completed works which are technically perfect but which are complete engineering failures. Some of these mistakes are unavoidable and they occur in connection with private as well as public undertakings.

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At one end of the scale of public undertakings we have works that are capable of reasonably strict engineering-economic analysis. We can say, with some assurance, that we are reasonably near the truth, that such-and-such a project, costing so much, will bring in the funds necessary to maintain and operate it and to amortize its cost, either in direct returns (such as tolls or assessments) or by creating taxable values which can be drawn upon for these purposes. In short, such a work can be definitely expected to add to the national wealth—to the productive earning power of a community, state or nation.

At the other end of the scale is the purely social undertaking, possessing, perhaps, some remote and intangible economic implications but primarily a humanitarian work, constructed for purposes of social uplift, and resting, therefore, on public opinion, on social philosophy, and on humanitarian ideals. Such projects should not be confused with wealth-producing enterprises.

The engineer, however, has no fault to find with such works *per se.* What he objects to is the policy of bringing such projects forward in the false habiliments of economic works, and then expecting him to justify them on the only basis which is humanly possible—namely, tangible economic values. Furthermore, he has had sufficient practice in handling economic matters to know that, in the end, such undertakings must be considered as luxuries, only to be afforded, no matter what one's social philosophy may be, as the surplus, achieved through the creation of actual wealth, permits such practical manifestations of charity.

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Events of recent years have brought into clearer perspective the necessity of relying on sound engineering advice instead of wishful thinking in the formulation of policies involving the expenditure of public funds on engineering enterprises. In the past, the public works policy of the federal government has been based, or at least has been supposed to be based, on economic considerations. Needless to say, many mistakes have been made, but, with few exceptions, only works that it was thought would aid in the economic development of the nation have been undertaken. On the other hand, the more recent policy is, apparently, not to wait for economic demand to develop, but, in the interests of social as well as economic progress, to anticipate and, presumably, to direct future developments.

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The engineer, realizing these dangers and difficulties, and jealous of his reputation, would in general advise low speed in an attempt to navigate this new and uncharted sea. Furthermore, he would advise that more effective efforts than ever before be made to separate the soundly economic from the purely social enterprise. He would be the last to deny that if social works are to be built, they should be planned and designed, as far as humanly possible, to furnish the desired service effectively and efficiently.

## List of New and Revised British Standard Specifications

(Issued during August and September, 1936)

B.S.S. No.

216—1936. *Vulcanized Fibre (Natural Colour) for Electrical Purposes.* (Revision.)
This specification states the requirements of vulcanized fibre sheets from 1/16 inch to 1 inch in thickness, intended for electrical purposes. A schedule of abridged tests recommended for material for specific uses is included

394—1936. *Short Link Wrought Iron Crane Chain. (Excluding Pitched or Calibrated Chain.)* (Revision.)
This specification relates only to sizes of chain up to and including 1½ inches and provides for two grades of chain, namely "Standard" quality and "Special" quality. An increased elongation under test load for the "Special" quality is also provided in this revision.

697—1936. *Rubber Gloves for Electrical Purposes.*
Specifies physical, mechanical and electrical tests for rubber gloves intended for electrical purposes in circumstances involving the possibility of direct contact with equipment of which the voltage does not exceed 3,300 volts to earth.

698—1936. *Papers (Unvarnished) for Electrical Purposes, excluding Asbestos Papers and those used in the Manufacture of Cables.*
This specification describes methods of test acceptable both to maker and user, and gives limits for various properties, leaving it to the purchaser to select the paper he requires for a particular purpose.

702—1936. *Silicon Aluminium Alloy Castings for General Engineering Purposes.*

703—1936. *Y-Alloy Castings (as Cast) for General Engineering Purposes.*

704—1936. *Y-Alloy Casting (Heat-Treated) for General Engineering Purposes.*
The above three specifications correspond generally to the British Standard Aircraft Specifications L.33 2 L.24 and L.35 respectively, differing principally in that to meet the requirements of a wider field of construction the aluminium used in the alloy may be of 98 per cent purity as well as 99 per cent and the repair of slight defects not affecting serviceability is specifically permitted, subject to the purchaser's sanction. Provision is also made for a porosity test to be carried out.

705—1936. *Method for the Determination of the Agglutinating Value of Coal.*
A standard method for use in the carbonization industries and in the coal export trade for the grouping of coals according to their agglutinating values.

706—1936. *Sandstone Kerbs, Channels, Quadrants and Setts.*
The specification lays down clauses for the quality of the stone to be used, the finish and dimensions of kerbs, channels, quadrants and setts. Methods for determining the resistance to crushing and the absorption of water are given in appendices.

707—1936. *The Testing of Mine Fans.*
Provides formulae and definitions, together with recommendations in regard to the measurement of pressure, air velocity and power of a mine fan.

708—1936. *Trailing Cables for Mining Purposes.*
Provides for 8 types of trailing cables for use underground with coal cutters. Six constructions are recommended as primary standards and two others are included as secondary standards.

(Issued during November, 1936).

B.S.S. No.

205—1936. *Glossary of Terms used in Electrical Engineering.* (Revision.)
Contains new sections dealing with television, cathode-ray tubes, electric lifts and electric welding, besides bringing up to date the definitions included in the previous edition.

415—1936. *Mains-Operated Apparatus for Radio, Acoustic and Visual Reproduction (Safety Requirements).* (Revision.)
Scope enlarged to cover radio apparatus for A.C. and D.C. mains and also "universal" sets (AC/DC). Includes also provisions for apparatus for visual reproduction.

709—1936. *Methods of Making a Cold Bend Test on Fusion Welded Joints.*
The Specification describes fully the factors which affect a bend test on a weld and lay down four different methods of test—two for determining the ductility of the weld metal and two for testing the joint as a joint.

Copies of the new specifications may be obtained from the Publications Department, British Standards Institution, 28, Victoria Street, London, S.W.1, and from the Canadian Engineering Standards Association, 79, Sussex Street, Ottawa, Ontario.

# Preliminary Notice

## of Applications for Admission and for Transfer

December 28th, 1936

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

The Council will consider the applications herein described in February, 1937.

R. J. DURLEY, Secretary.

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*The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years inthe case of a candid ate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of,age, and shall have been engaged in some branch of engineering for at least six years which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch ofengineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more year.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equiva ent standard.

**A Student** beshallat least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

**The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.**

### FOR ADMISSION

CARR—NOEL OSMOND, of Ottawa, Ont., Born at Ottawa, Dec. 20th, 1887; Educ., Grad., R.M.C., 1909. With the R.C.A. to date as follows: Lieut., 1909; Capt., 1914; Brevet Major, 1916; Major, 1922; 1929-35, Brevet Lieut.-Col., and at present Colonel. For over six years charged as technical adviser to the Department of National Defence on all matters relating to Artillery equipment, whether concerned with design, production or operation. At present, Director of Mechanization and Artillery, Dept. of National Defence, Ottawa, Ont.
References: A. G. L. McNaughton, E. W. Stedman, G. R. Turner, R. W. Boyle, C. Camsell.

DEY—GORDON A., of 950 William St., London, Ont., Born at Wingham, Ont., April 23rd, 1904; Educ., Three years Technical School; 1923-35, chief dftsman., Dennisteel Ltd.; 1935-36, dftsman., Canada Creosoting Co. Ltd.; At present, production manager, Dennisteel Corporation Ltd., London, Ont.
References: D. S. Scrymgeour, H. A. McKay, H. L. Hayman, H. H. James, F. R. Phillips.

HOGG—ALLAN DOUGLAS, of 9 Temple Ave., Toronto, Ont., Born at Landis, Sask., Aug. 27th, 1913; Educ., B.Sc. (Mech.), Univ. of Sask., 1935; 1935 (2 mos.). asst., Dom. Govt. water survey in Sask.; 1935 (2 mos.), R.C.A.F., Camp Borden; 1935-36, demonstrator, Univ. of Sask.; 1936 (2 mos.), turbine attendant, power plant, Sask.; 1936 (4 mos.), asst., timber mech. divn., Forest Products Labs., Ottawa; Oct. 1936 to date, factory course, Massey Harris Co., Toronto, Ont.
References: C. J. Mackenzie, A. R. Greig, I. M. Fraser, W. E. Lovell, E. K. Phillips, T. A. McElhanney, W. E. Wakefield.

HURTER—ALFRED THEODORE, of Iroquois Falls, Ont., Born at Frankfurt A/M, Germany, July 3rd, 1897; 1915-19, completed four-year civil engrg. course, Ecole Polytechnique Federale, Zurich, Switzerland; R.P.E. of Quebec; 1919 (summer), triangulation work, Swiss Federal Topographical Divn.; 1919-20, designing dftsman., for cement mills, Brown & Pooley Ltd., consltg. engrs., London, England; 1920-23, partner, Huber & Hurter, contractors, Bucharest, Rumania, various constrn. work of industrial nature; 1923-24, designing dftsman., Nfld. Pulp and Paper Co. Ltd., constrn. of new paper mill for Corner Brook; 1924-28, designing engr., George F. Hardy, M.E.I.C., consltg. engr., New York; pulp and paper mill designs for Canada and U.S.A.; 1928-29, res. engr., in charge of extension of paper mill, St. Lawrence Paper Mills Co. Ltd., Three Rivers; 1929 to date, res. engr., Iroquois Falls Divn., Abitibi Power and Paper Co. Ltd., Iroquois Falls. Also consltg. engrg. work for other Abitibi divns. and subsidiaries.
References: J. Stadler, W. I. Bishop, G. F. Hardy, H. S. Taylor, H. L. Trotter, J. A. DeCew, P. A. Trost, D. C. Tennant, F. O. White.

JOMINI—JOHN LOUIS, of Grand'Mere, Que., Born at Grand'Mere, Apr. 28th, 1913; Educ., 1932-35, McGill Univ., completed second year engrg. with exception of two subjects, calculus and physics; Five months work with millwrights, and two years to date, in the dfting office, Consolidated Paper Corporation, Grand'Mere, Que.
References: E. B. Wardle, W. B. Scott, H. G. Timmis, H. O. Keay, W. B. Scoular.

SHAW—FREDERICK W. B., of 167 Birch Ave., St. Lambert, Que., Born at Montreal, May 22nd, 1911; Educ., B.Eng., McGill Univ., 1934; 1934-35 (6 mos.), St. Lawrence Power Co.; 1935 (4 mos.), Canadian Marconi Co.; 1935 to date, junior engr., Steel Co. of Canada, Ltd., Montreal, Que.
References: E. C. Kirkpatrick, J. C. Antliff, H. C. Karn, C. V. Christie, L. O'Sullivan.

### FOR TRANSFER FROM THE CLASS OF JUNIOR

GRIME—LEONARD, of 65 Sanford Ave. So., Hamilton, Ont., Born at Stretford, Lancs., England, May 26th, 1904; Educ., B.A.Sc., Univ. of Toronto, 1926; Summers: 1923, estimator, Duluth-Superior Dredging Co., Detroit; 1924, survey work, City of Royal Oak Engrg. Dept.; 1925, survey work, real estate subdivns. in Detroit; 1926, reinforced concrete dftsman., Truscon Steel Co., Detroit; 1927-1929, struct'l. dftsman., American Bridge Co., Toledo, Ohio; 1929-31, struct'l. dftsman., Standard Steel Constrn. Co., Welland, Ont.; 1931 (July-Oct.), struct'l. dftsman., Hamilton Bridge Co.; 1933-36, mtce. and constrn. work, National Silicates, New Toronto, Ont., estimating, design, erection, field work in connection with new plant; 1936 (Apr.-June), struct'l. dftsman., Canadian Bridge Co.; June 1936 to date, struct'l. dftsman., Hamilton Bridge Co., Hamilton, Ont. (*Jr. 1928.*)
References: R. K. Palmer, J. A. McFarlane, D. T. Alexander, R. E. Smythe, D. D. Whitsun, C. R. Young, C. H. Mitchell.

### FOR TRANSFER FROM THE CLASS OF STUDENT

CHOROLSKY—EUGENE, of Walkerville, Ont., Born at Tsitsihar, Manchuria, Mar. 2nd, 1905; Educ., B.A.Sc., Univ. of Toronto, 1926; Summers 1923-24-25, inspr. on reinforced concrete culverts, arch and beam bridges, testing cement and aggregates for concrete. Dept. of Highways, Sask.; 1926 to date, with the Canadian Bridge Co. Ltd., Walkerville, Ont. Making and checking shop details, layouts, estimates, etc., on all types of bldgs., transmission structures, fixed bridges, moveable bridges, turntables, ferry aprons and mech. parts for same; plant layout; designing and estimating; devising and designing erection methods for all types of bridges and bldgs.; res. engr. on constrn. (*St. 1926.*)
References: A. P. Linton, D. T. Alexander, F. H. Kester, G. V. Davies, A. E. West, F. Stevens, R. C. Leslie.

CAIRNCROSS—ALEXANDER THOMAS, of Chengtu, China, Born at Toronto, Ont., July 31st, 1908; Educ., B.Sc. (Civil), Queen's Univ., 1931; 1926-27, office and field constrn. and equipment, Stirling Appraisal Co. Ltd., Toronto; 1928 (5 mos.), London rural power line constrn., H.E.P.C. of Ont.; 1929 (5 mos.), 1930 (3 mos.), activated sludge plants, storm and domestic systems, Wynne-Roberts Son & McLean, Toronto; 1930 and 1932 (5 mos.), sewers and pavements, Ryan Contracting Co. Ltd.; 1931-32, chief dftsman. of surveys and Minden, Dept. of Northern Development Ontario; 1933-34 (7 mos.), relief camps; April 1935 to date, technical advisor, Dept. of Engrg., Generalissimo Staff, National Government of China. Advising on highway alignment in Prov. of Szechwan. New survey line through areas where motor cars have never been seen. Reports on gasoline usage, transportation and the wood oil industry. (*St. 1928.*)
References: A. Macphail, L. T. Rutledge, W. P. Wilgar, D. S. Ellis.

KOEHLER—JULIUS WILBUR, of Montreal, Que., Born at Stratford, Ont., Apr. 8th, 1908; Educ., (B.Sc. (E.E.), McGill Univ., 1930; Summers: 1927, land surveying S.W. Sask.; 1928, elect'l. helper, C.P.R., Winnipeg; 1929, elect'l. helper, H.E.P.C. of Ontario; 1930-31, elect'l test course, and 1931-32, illuminating engr., Can. Gen. Elec. Co. Ltd.; 1934 (Sept.-Dec.), teaching elect'l. theory and testing, London Technical School; Dec. 1935 to date, lighting service engr., Can. Gen. Elec. Co. Ltd., Montreal, Que. (*St. 1929.*)
References: G. H. Gillett, W. J. Armstrong, C. V. Christie, W. M. Cruthers.

STRATTON—FREDERICK STEPHEN, of 2 Donovan Court, 97 Drayton Gardens, London, S.W.10, England. Born at Birmingham, England, Jan. 24th, 1907; Educ., B.Sc. (E.E.), Univ. of Man., 1930; 1927 (summer), rodman, inspr., Manitoba Power Co.; 1928, rodman, City of Winnipeg Hydro; 1928-29, dftsman., rly. and power house constrn., City of Winnipeg Hydro; 1930 (May-Oct.), field engr., Manitoba Power Co.; 1930-32, field supt., North Western Power Co., trans line constrn.; 1932 (Aug.-Sept.), elect'l. engr. on expedition to study Eclipse of the Sun at Lake Magog, Que., with British Astronomical Party; Apr. 1933 to date, asst. in charge of supervision of various factories in England with Chloride Electrical Storage Co. Ltd., London, England. (*St. 1928.*)

References: E. P. Fetherstonhaugh, E. V. Caton, A. E. Macdonald, G. H. Herriot, L. M. Hovey, H. L. Briggs, W. E. Lovell.

TARR—FRANCIS GILBERT AUBREY, of 387 Reid St., Peterborough, Ont., Born at Salford, nr. Bristol, England, July 26th, 1904; Educ., B.A.Sc., 1926, Ph.D., 1935, Univ. of Toronto. M.S., Cornell Univ., 1932; 1926, students' course, 1927-31 and 1935 to date, switchboard engr. dept., Can. Gen. Elec. Co. Ltd., Peterborough, Ont. (*St. 1926.*)

References: H. R. Sills, E. R. Shirley, T. E. Gilchrist, A. L. Dickieson, B. I. Burgess.

## John Loudon Macadam, 1756-1836

On October 30th, at Ayr, the centenary of the death was commemorated of the famous road-maker, John Loudon Macadam, who was born in Ayr on September 23rd, 1756, and died at Moffat, November 26th, 1836, at the age of eighty. The commemoration included a luncheon at the County Buildings, at which the toast "The Memory of John Loudon Macadam" was proposed by Mr. Hore-Belisha, Minister of Transport, and at which a paper on the life and work of Macadam was read by Mr. G. S. Barry, County Surveyor of Ayrshire. After the luncheon, Mr. Hore-Belisha unveiled a bronze memorial tablet to Macadam, which has been erected in Wellington Square by the Institution of Municipal and County Engineers, as the representative body of highway engineers in Great Britain. When speaking at the luncheon, Mr. Hore-Belisha said that Macadam pleaded consistently that the design and maintenance of roads should be entrusted, not, as was the casual fashion, to amateurs and sinecurists, but to those understanding what he claimed to be a science and having practical experience in its application.

The earlier part of Macadam's career had nothing to do with engineering of any sort, for as a boy of fourteen, his father being dead, he was sent to an uncle, William Macadam, in New York, and it was in his office he learnt those business habits which marked his whole life. That he was successful as a business man is evident from the fact that by 1783 he was able to return to his native country and settle down to the life of a country gentleman. Information as to Macadam's activities, said Mr. Barry, in his paper, is not readily obtainable, but it appears his first incursion into the field in which he was to become famous was the construction of a road to his estate. In 1787, he became one of the Road Trustees in his district, and as such served five years. His interests then apparently became centred in the business of Messrs. The British Coal Tar Company, which the ingenious Lord Dundonald had founded at Muirkirk for the production of tar, lamp-black, paint and other substances. His association with Ayr was a close one and he became a Councillor, a Justice of the Peace, and, when an invasion scare led to the formation of a corps of volunteers, he was recommended for the position of Captain, and by George III was granted a commission as a Major.

In 1798, the year which saw the beginning of the Napoleonic Wars, Macadam, who, in America, had been connected with the sale of war prizes, was appointed an agent for the revictualling of the Navy at the western ports, and took up his headquarters at Falmouth. His hobby of road-making was, however, ever present in his mind, and in 1811 he presented a report to a Committee of the House of Commons on Roads. The war over, Macadam, in 1816, at the age of sixty, began the work he will always be remembered for. He had served for some years as a Trustee of various local Road Trusts, and now, in 1816, he was appointed General Surveyor of Roads to the Bristol Turnpike Trust, and by 1818 was acting as consulting surveyor to no fewer than 34 similar bodies. From this time onwards, he was incessantly writing reports, supervising and advising. His "Remarks on the Present System of Road-making" was published in 1816; his "Practical Essay on the Scientific Repair and Preservation of Roads" in 1819, and his "Observations on the Management of Trusts for the Care of Turnpike Roads" in 1825. From these works, his reports and other documents, Mr. Barry quoted at length, illustrating the methods used by Macadam, and his views on all that appertained to roads. When he had reached the age of sixty-nine he resigned his position at Bristol, only, however, two years later to be appointed by Parliament Surveyor General of Roads, a position he still held at the time of his death. "While it can hardly be said," said Mr. Barry, "that Macadam was the inventor of the system which he practised, it is nevertheless the case that he perfected that system and raised it to its highest standard. . . . His contribution to the advancement of roads was without doubt one of the great features of the early Nineteenth Century."—*Engineering.*

## Fifth International Congress for Applied Mechanics (1938)

The American Committee, to whom responsibility for organizing the Fifth International Congress for Applied Mechanics was delegated by the International Committee at its meeting at Cambridge University, England, in July, 1934, announces that the Fifth Congress will meet in Cambridge, Massachusetts, U.S.A., September 12th-16th, 1938, at Harvard University and the Massachusetts Institute of Technology. As in the past, this Congress is to be a meeting of persons working in the field of Applied Mechanics before whom reports of recent work may be presented for discussion.

The programme will cover three main divisions of Applied Mechanics as follows:

I. Structures, elasticity, plasticity, fatigue, strength theory, crystal structure.

II. Hydro and aerodynamics, gasdynamics, hydraulics, meteorology, water waves, heat transfer.

III. Dynamics of solids, vibration and sound, friction and lubrication, wear and seizure.

Following the meeting at Cambridge, Mass. it is expected that arrangements will be made to visit Washington (National Bureau of Standards), and Langley Field (National Advisory Committee for Aeronautics).

Dormitory and boarding facilities will be made available by Harvard University.

Inquiries should be addressed to the Fifth International Congress for Applied Mechanics, Massachusetts Institute of Technology, Cambridge, Mass., U.S.A.

TH. VON KARMAN, J. C. HUNSAKER } *Secretaries.*

## Steam Heating on Electric Trains

The heating of passenger trains by steam, particularly in these days of large boilers, is a fairly simple matter. A considerable supply of steam at considerably higher pressure than is required is usually available and can be tapped through a reducing valve; but in countries where trains, normally steam hauled, cover long distances behind electric locomotives, the matter is not so easily solved and special arrangements have to be made.

Such operation is frequent in the United States, where a standing Committee on Electric Rolling Stock of the Mechanical Division of the American Railroads Association has, among other matters, had under consideration the steam heating of trains hauled by electrical locomotives. They have had before them replies to a questionnaire giving the summarized experience of four of the leading companies, and it is clear from these replies that the demand made by steam heating is considerable. While definite figures do not appear to be available, the consensus of opinion indicates a consumption of about 250 pounds of steam per car per hour, with a pressure drop of 8 to 10 pounds per car, and, with modern trains of 18 cars or more, this means that the consumption may exceed 4,500 pounds of steam per hour, while an initial pressure of 175 pounds per square inch will be required behind the locomotive.

For this purpose vertical fire tube boilers, burning oil fuel, seem to have been universally adopted. One railway originally tried vertical tube flash boilers, but these proved unsatisfactory in service and prohibitively heavy in maintenance cost. In the earlier boilers a working pressure of 100 to 120 pounds per square inch was used, but for modern requirements 200 to 220 pounds pressure has been found necessary, with a normal output rate of 3,250 to 4,700 pounds of steam per hour, from and at 212 degrees F., and twice this evaporation under forced ratings. Superheaters and feedwater heaters have been installed with satisfactory results. It may be added that the steam consumption of boiler auxiliaries is found to be by no means negligible and has been estimated by one railway, the Chicago, Milwaukee, St. Paul and Pacific, as, for atomizing 300 pounds per hour, feed pump 230 pounds., blower 150 pounds., oil pump 150 pounds., total 890 pounds per hour. The same railway reports that burning heavy crude oil sometimes gives trouble with "gassing," which is particularly undesirable where open observation cars are in use, and for the past three years on their Rocky Mountain section they have been burning a light crude oil, which with careful firing gives no trouble in that respect.

In order to reduce pressure drop a 2-inch pipe line has been standardized and a larger size has been tried, the capacity of the system being governed by the maintenance of a minimum pressure at the last car. One company lays down a minimum at the end of the train of 5 pounds per square inch for steam heating, and adds that if the steam is used alternatively for air conditioning a minimum of 55 pounds pressure at the last car must be maintained. The pressures used having put rubber hose connections out of the question, flexible metallic connectors are universal, and it is stated that if these are well insulated a saving of 10 per cent in loss as compared with uninsulated connectors is obtained. This is an important consideration, affecting not only boiler capacity, but the quantity of feedwater it is necessary to carry, a by no means inconsiderable figure, amounting in one case to 3,000 gallons, as much as is carried in many steam locomotive tenders in this country. It is agreed that the actual steam consumption varies widely in practice, depending on the type of car, weather conditions, speed, difference between internal and external temperatures, and the condition of the equipment. To conserve the steam supply the Committee recommend the fitting of a reducing valve in each coach, as apart from other considerations, the amount of space required in the electric locomotive for the heating equipment is becoming a serious matter.—*Engineering.*

## EMPLOYMENT SERVICE BUREAU

The Service is operated for the benefit of members of The Engineering Institute of Canada, and for industrial and other organizations employing technically trained men—without charge to either party.

*All correspondence should be addressed to*

**The Employment Service Bureau, The Engineering Institute of Canada**
**2050 Mansfield Street, Montreal**

## Situations Vacant

ENGINEERING GRADUATE, with mechanical and sales ability. Out of school three or four years, who would like to become associated with a contracting and manufacturing concern in heating, ventilating and air conditioning work. State qualifications and experience to Box No. 1429-V.

YOUNG ELECTRICAL OR MECHANICAL ENGINEER, wanted at once for position of superintendent 2,000 h.p. steam electric generating station. Practical experience similar plant desired. Write full particulars to Box No. 1434-V.

SALES ENGINEER, to organize sales branch in province of Quebec, familiarity with transmission and pulp and paper machinery advantageous. The product has high reputation in all industrial countries of the world, but only recently introduced in Canada. Applicants are asked to give full particulars in first letter stating education, early training, industries most familiar with, and whether bilingual. A per iod of training in Ontario field purposed. Apply to Box No. 1439-V.

### The Civil Service Commission

ASSISTANT MECHANICAL ENGINEER (25864)

25864.—An assistant mechanical engineer, in the Chief Architect's Branch, Department of Public Works, Ottawa, salary rate of $2,220 per annum, subject to a deduction of five per cent during the fiscal year beginning April 1, 1936. Temporary appointment may be made at this time, this examination will qualify for permanent appointment. For such employment the initial salary of $2,220 per annum may be increased upon recommendation for meritorious service and increased usefulness at the rate of $120 per annum until a maximum of $2,700 has been reached.

*Duties.*—To assist in designing and preparing plans and estimates of mechanical equipment and heating, ventilating, power, light, telephone and signal systems; to supervise the construction, installation, maintenance and repair thereof; and to perform other related work as required.

*Qualifications required.*—High school graduation; either graduation in mechanical engineering from a university of recognized standing with three years of practical mechanical engineering experience or eight years of practical engineering training and experience; in either case one year of the experience shall have been in a position of professional responsibility; corporate membership in The Engineering Institute of Canada or membership in a provincial association of professional engineers, or qualifications which would permit of such membership; considerable machine, forging and casting shop experience; tact and ability to handle men. While no definite age limit has been fixed, age may be a determining factor in making a selection.

Application forms properly filled in must be filed with the Civil Service Commission, Ottawa, Ont., **not later than January 21, 1937.**

Application forms may be obtained from the offices of the Employment Service of Canada, from the Postmasters at any City Post Office, The Engineering Institute of Canada, Montreal, or from the Secretary of the Civil Service Commission, Ottawa.

Please quote competition number when filling out application forms.

## Situations Wanted

INDUSTRIAL ENGINEER AND SUPT. Age 31, A.M.E.I.C., with combined electrical, mechanical and steel industry experience. Experience includes design and testing of all types of industrial electrical equipment, supervision of production and cost reduction, heat treating of steel, time study application in several plants. At present supt. of modern factory. Apply to Box No. 132-W.

ELECTRICAL ENGINEER, B.sc., E.E. Age 30. Completed C.G.E. Test Course; five years experience with power company utility work—substation and power house (steam) operation and maintenance, transmission and distribution line operation, maintenance and design. Industrial or utility work desired. Location immaterial. Available on short notice. Apply to Box No. 266-W.

DESIGNING DRAUGHTSMAN, experience in layout of steam power house equipment and piping. Wide experience in mechanical drive and details of machinery, gearing, and hoists. Accustomed to layout of small mill buildings of steel and timber, structural design and details. Good references. Present location Montreal. Apply to Box No. 329-W.

## Situations Wanted

ENGINEER, A.M.E.I.C. Age 30. Single. Employed. Civil and mining experience, capable of designing and superintending construction of timber, concrete and steel structures, rock crushing and ore plante. Would consider position with mining or engineering company designing and building mills. Apply to Box No. 431-W.

MECHANICAL ENGINEER, B.ec. Age 31. Married. Last ten years includes:—Mechanical structural and reinforced concrete design in pulp and paper mills, industrial plants, hydro-electric, mine, sewers and sewage disposal plant construction. My experience also includes shop production, steam plant combustion, fuel analysing, inspecting, supervising and instrument work on industrial construction. Permanent position preferred. Apply to Box No 521-W.

DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aero-photographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.

DESIGNING ENGINEER AND ESTIMATOR, grad. Univ. of Toronto in C.E., A.M.E.I.C., twenty years experience in structural steel, construction and municipal work. Available at once. Apply to Box No. 613-W.

### Employment Service Bureau

Enquiries during the past month indicate that the greatest demand for engineers appears to be in the following general classifications:—

- Recent graduates in mechanical engineering.
- Recent graduates in civil engineering.
- Young mechanical engineers
- Sales engineers in all branches of engineering.
- Sales engineers speaking French.
- Engineers with pulp and paper mill experience in design, draughting and maintenance.

If your experience is in any one of the above classifications, why not register with The Institute's Employment Service Bureau. Our list of men available for positions is greatly reduced in number.

ELECTRICAL ENGINEER, B.ec. '28; M. Eng. '35. Two years student apprenticeship at Can. Westinghouse Co., including test and electrical machine design. Also about two years experience in operating dept. of large electrical power organization. Available on short notice. Apply to Box No. 660-W.

MECHANICAL AND STRUCTURAL ENGINEER. Six yeare experience with prominent manufacturer, designing, heating and power boilers, boiler installations, coal and ash handling equipment. Good practical knowledge of steel plate work welding. Also wide experience in designing, estimating and detailing structural steel for buildings and bridges. Good education. Have held position of responsibility. Above can be verified by best of references. Available at once. Apply to Box No. 692-W.

ELECTRICAL AND CIVIL ENGINEER, B.sc. Elec. '29, B.sc. Civil '33. JR.E.I.C. Age 29. Experience includes four months with Can. Gen. Elec. Co., approximately three years in engineering office of large electrical manufacturing company in Montreal, the last six monthe of which was spent as commercial engineer. For the last year and a half employed in electrical repair shop. Best of references. Apply to Box No. 693-W.

ELECTRICAL ENGINEER, B.ec., University of N.B., '31. Experience includes three months field work with Saint John Harbour Reconstruction. Apply to Box No. 722-W.

CIVIL ENGINEER, B.ec. (Alta. '31), E.E.I.C. Experience includes three seasons in charge of survey party. Traneitman on railway maintenance, and concrete bridge designing. Nature of work and location immaterial Apply to Box No. 724-W.

## Situations Wanted

YOUNG CIVIL ENGINEER, B.ec. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

MECHANICAL ENGINEER, S.E.I.C., B.A.ec., Univ. of B C. '30. Single, age 24. Sixteen months with the Allis-Chalmers Mfg. Co. as etudent engineer. Experience includes foundry production, erection and operation of steam turbines, erection of hydraulic machinery, and testing texropes and centrifugal pumps. Location immaterial. Available at once. Apply to Box No. 735-W.

CIVIL ENGINEER, M.ec., A.M.E.I.C., R.P.E. (Ont.), ten years experience in municipal and highway engineering. Read, write and talk French. Married. Served in France. Will go anywhere at any time. Experienced journalist. Apply to Box No. 737-W.

RADIO AND ELECTRICAL ENGINEER, B.Sc., '31, JR.E.I.C. Single. Age 29. One year and a half actual field experience in power and lighting equipment. Extensive work in telephone and radio layouts in switchboard and installation depts. Particularly interested and experienced in sales and traffic work in telephone and radio company. At present supervisor over sales and service of radio and electrical company. Available on short notice. Location immaterial. Apply to Box No. 740-W.

CIVIL ENGINEER, B.sc. '29, A.M.E.I.C. Married. One year building construction. One year hydro-electric construction in South America, eighteen months resident engineer on highway construction, one year on harbour design and construction. Working knowledge of Spanieh. Apply to Box No. 744-W.

PLANT ENGINEER or SUPERINTENDENT, capable of eupervising all phases of industrial plant operation, graduate electrical, eleven years diversified industrial experience including test course, four years on large Quebec industrial development, on construction and operation, also six years with prominent consulting firm supervising electrical and mechanical engineering projects. Age 31, single. Apply to Box No. 795-W.

CIVIL ENGINEER, B.ec. '15, A.M.E.I.C., married, extensive experience in responsible position on railway construction, also highways, bridges and water eupplies. Position desired ae engineer or superintendent. Available at once. Apply to Box No. 841-W.

STRUCTURAL ENGINEER, B.A.ec., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

CHEMICAL ENGINEER, B.sc. (McGill '21), A.M.E.I.C., age 36, married; three years since graduation with pulp and paper mills; eight years in shops, estimating and sales divisions of well-known gas engineering and construction companies in the United States. Excellent references. Available on short notice. Apply to Box No. 866-W.

ELECTRICAL ENGINEER, graduate 1929, S.E.I.C. Single. Experience includes two years with electrical manufacturing concern and one on highway construction work. Available at once. Will go anywhere. Apply to Box No. 887-W.

CIVIL ENGINEER, B.A.SC., JR.E.I.C., age 32, married. Two years in pulp mills draughting and designing additions, maintenance and plant layout. Three and a half years in the Toronto Building Department, checking and designing for steel, reinforced concrete and ordinary structures. One and a half years as transitman and draughtsman on road location and maintenance work. Available at once. Location immaterial. Apply to Box No. 899-W.

CIVIL ENGINEER, B.ec., O.P.E. Experience includes several years on municipal work-design and construction of sewers, steel and concrete bridges, watermains and pavements Available at once. Apply to Box No. 950-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.

ELECTRICAL ENGINEER AND GEOPHYSICIST. B.sc. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

ELECTRICAL ENGINEER, B.ec.E.E. (Univ. of N.B. '31). C.G.E. Test Course included industrial control, induction motors and transformers; the transformer test included desk work for two months on computing losses, efficiencies, etc. Available at once. Apply to Box No. 1119-W.

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No. 1168-W.

ENGINEER, with twenty years experience in industrial, pulp and paper mill, and general engineering and design. Age 41. Last five years chief engineer of paper mill making newsprint specialties and toilet tissues. Apply to Box No. 1246-W.

ELECTRICAL ENGINEER, B.Sc. '34 (Univ. of N.B.), S.E.I.C. Age 21, single. Desires any kind of electrical work. Will consider any location. Apply to Box No 1262-W.

ENGINEER AND DRAUGHTSMAN, Jr.E.I.C., age 33, married. Diplomas from Mtl Tech. Inst. in R.C. and Structural Design. 11½ years experience in civil engineering, draughting and instrument work. This includes 7 years with M.L.H. & P. Cons. as field engineer on construction and maintenance of gas mains. Present location Montreal. Available at once. Apply to Box No. 1326-W.

CIVIL ENGINEER, M.E.I.C. Married. Age 38. Twenty years experience in organization, design and estimating, and cost accounting. Active service in France. Apply to Box No. 1367-W.

ENGINEER SUPERINTENDENT, A.M.E.I.C., R.P.E., Que. and Alta. Age 47. Married. Twenty years experience as engineer and superintendent in charge of hydro-electric, industrial, railroad, and irrigation construction. Specialized in rock excavation and suction dredging. Intimate knowledge of costs, estimating and organizing. Available immediately. Apply to Box No. 1411-W.

CIVIL AND ELECTRICAL ENGINEER, Univ. of Man. '35 and '36. S.E.I.C. Experience in irrigation and mapping. Available at once. Location immaterial. Box No. 1418-W.

CIVIL ENGINEER, B.Sc. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

SALES ENGINEER, M.E.I.C. Age 50. Married. Several years in combustion and general machinery lines. Estimating and layout work (mechanical and electrical). Speaking French fluently. Executive ability. Apply to Box No. 1482-W.

MECHANICAL ENGINEER, 1935 graduate, B.E., (N.S. Tech. Coll.), age 24, single. Experience includes one year's work in a testing laboratory, summer work in foundry, boiler, and machine shops, draughtsman and timekeeper, road inspection on special asphalt. Keenly interested in plant control work, draughting, drying and refrigeration as applied to foods. Available on short notice. Apply to Box No. 1500-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

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## The Wonders of Plastics

Laminated resin products are proving their worth, for instance, for heavy bearings, while in chemical works and factories in which corrosive vapours or liquids have to be handled they have found many special fields. For example, a fan of the material will handle without injury corrosive vapours such as hydrochloric-acid gas, even at a temperature of 100 degrees C. In a recent test one such fan delivered 1,600 cubic feet of this gas per minute at 17 inches w.g., when operating at 2,300 r.p.m. under such conditions. In the matter of piping the material is likewise creating a field for itself and the following figures give some idea of what it is capable of withstanding. A flanged pipe 2 inches i.d. and 2.43 inches o.d., subjected to a hydraulic test at 225 pounds per square inch pressure, showed only slight leakage at the flange threads at the ends; it was not until the pressure reached 1,300 pounds per square inch that leakage appeared at a few pin holes along the pipe. As this piping was intended to be used at pressures of only 50 pounds per square inch, the margin was obviously ample.

As auxiliary materials in the engineering industry the field of plastics is constantly widening. One such field is in the varnish and lacquer industries. In the past few years quite a new manufacturing technique has been developed in these trades, with an accompanying reduction in the cost of raw materials, a simplification of the compounding processes, and an improvement in the finished products. This is due, to a large extent, to the fact that good-quality synthetic resins of uniform composition are now available, while the other half of the varnish—the solvent—has been considerably reduced in cost by the introduction of new hydrogenated solvents from coal. These solvents include hexaline from the hydrogenation of phenol; methyl hexaline from cresol; and tetraline and decaline obtained by hydrogenating naphthalene. All these have great dissolving power for synthetic resins. Coumarone resin varnishes are now made in three distinct types, viz., spirit, oil, and chemically-resistant. Spirit varnish is prepared by simply dissolving the coumarone resin in tetraline or other solvent. The making of oil varnish is simplified by first dissolving the resin in one of the hydrogenated solvents before introducing oil and driers. Due to its resistant properties, coumarone resin is being applied as a coating for ships' bottoms and other structures in contact with sea water. Both coumarone resin and resins of the bakelite type are employed for coating storage tanks and other containers, specifically for the storage of coal-tar derivatives, petrol containing tetra-ethyl lead, and other petroleum products. Small containers, such as barrels and cans, are often lined internally with a coating of synthetic-resin varnish.

British manufacturers have, of late, taken up the production of urea—one of the raw materials for urea-formaldehyde resins—and their factories are now turning out enough to supply all demands of the home market. A considerable fall in price has resulted, and this, in turn, has enabled the laboratory processes for making urea resins to be carried out on a commercial scale. Resins of this class, besides finding application in varnish making, are coming into favour in other directions not usually associated with the plastics industry. For example, the fusible resins are marketed in the form of solutions in water, and are employed in the building trade as a priming coat for plaster and for wood surfaces, and also in the textile industries for waterproofing fabrics and for the preparation of size. The electrical industry also makes use of them, particularly of those produced with an acid catalytic agent, these having, it is said, the greatest insulating value. Besides the coating of paper and fabric insulation with urea resin varnish, the resin itself is used as a binder for finely-divided iron in the manufacture of certain magnet cores.

Perhaps the most interesting outcome of work on urea resins is the new so-called "organic glass," which is a special type of the resin, unfilled, but rendered infusible by heat as in moulding. This substance is superior to glass in some respects, but inferior in others. It weighs only about half as much, which renders it advantageous for aircraft, and it is not splintered by a bullet or shell fragment, but its transparency, while equal, in the new condition, to that of glass, is liable to suffer with use as its surface, being softer, is easily scratched and disfigured. Strong chemicals, like acids, to which glass is generally inert, also gradually attack it. Organic glass is readily machinable and may be treated in the workshop exactly as is done with laminated or bakelite mouldings. Its tensile strength approaches 4 tons per square inch, whilst the compression resistance is about 14 tons per square inch.

—*Engineering.*

## The Dover Dock for the Cross-Channel Train-Ferry Service

An important new departure in cross-channel traffic will be inaugurated on October 14th next, when the first passenger train utilizing the train-ferry service between Dover and Dunkerque will leave Victoria station . . . The service is for both passengers and goods, and the former, if they so desire, can entrain at Victoria station and remain in their compartment until Paris is reached . . . It is proposed to run a service in both directions each night, the Paris train leaving Victoria at 10 p.m. and the London train leaving the Paris Nord station at 9.50 p.m . . . The cars are adapted for running over both the British and French gauges. Specially wide wheel treads are employed, as the two rail gauges differ by half-an-inch.

Before deciding to locate the sea terminus at Dover, every possible alternative location was studied. All likely sites at Dover were then closely examined and the form of construction of the terminal carefully considered. The extreme variation between the highest and lowest water level is 25 feet, and this precluded the adoption of an inclined approach in the form of a bridge, as such an approach would have had to be about 500 feet in length to give a suitable incline over which sleeping cars could pass. In addition, the weather conditions in Dover harbour are frequently severe, so that the mooring of the ship to such a bridge might often have been impossible. It was finally decided to build an enclosed dock, with powerful pumps to regulate the water level to the required height in the shortest possible time.

In addition to the dock, an approach jetty, 400 feet long by 30 feet wide, has been constructed, alongside which the vessels will lie before entering the dock. This jetty was formed of concrete piers enclosed in sheet-steel piling. From the jetty, the vessels will be warped through the open gates into the berth, after which the gates will be closed and the water raised or lowered to the required level by means of the pumps. When the vessel is at the required level, connection to it will be made at the inner end of the dock by means of a bridge 70 feet long. This bridge will normally be approximately level, but as loading and unloading of the trains on to the vessel takes place there will naturally be some tilting both longitudinally and sideways of the vessel. The bridge is a complete articulated structure, being constructed to take up any difference in level caused by the tilting, and it can be raised clear of the vessel when necessary. A large steel pin at the end of the vessel will enter a recess which has been formed in the bridge. Two lines of rail track cross the bridge, so that it will be possible for two lines on the vessel to be dealt with at the same time. The passage of all traffic between the railway lines on the shore and the vessel will be controlled by a complete electric signalling and interlocking installation. Ordinary locomotives will be used for transferring the railway vehicles between the boat and the land. In association with the dock, a customs house is being constructed, and this will also contain the usual railway offices. A transit shed will form part of the terminal station, containing considerable space for bonded stores. Special facilities are provided for the transit of motor-cars, for which a large garage is provided on the upper deck of the ships. In conclusion, it may be mentioned that on the French side, locks were already in existence at Dunkerque, and comparatively little adoption has been required. More than fifteen hundred wagons have been built for the freight service, and it will be possible to send goods direct to any part of the Continent except Russia and Spain, where the gauge is different . . . —*Engineering.*

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## CONTENTS



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# THE ENGINEERING JOURNAL

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# Forest Management in Ontario


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**An address delivered before the Toronto Branch of The Engineering Institute of Canada, November 19th, 1936.**

*(Slightly Abridged)*

Engineering and forestry have much in common. They both employ the scientific approach to their problems and they both build for the future as well as for the present. In fact the superstructure of forestry is raised from a triangular foundation in the knowledge of biology, engineering and economics.

The biological foundation of forestry is quite evident because trees, and other plants and the animals which affect their lives, are living things. In fact a forest is a biological community with its members acting and reacting on each other much like a community of human beings.

The engineering base of forestry becomes evident when we consider the fact that a forester may be called upon to establish boundaries and make topographic maps, to construct lookout towers and telephone lines, to make roads and trails, to build chutes and flumes, to understand the mechanics involved in the use of logging and milling equipment and to build dams and improve streams for log driving purposes.

Even without the examples given above, we could maintain legitimately that forestry, considered only as the art of growing successive wood crops, is an engineering profession. Engineering has been defined as the "art of directing the great sources of power in nature for the use and convenience of man." A forest is principally the product of the rainfall, soil, sunshine and temperature of its environment, and forestry the art of controlling the forces of nature in the forest to supply in perpetuity the wood-using needs of man.

For the reasons outlined above, foresters should be accepted as a part of the engineering profession. As a matter of fact, of the four forestry schools in Canada, three grant the degree of Forest Engineer, one as an undergraduate and two as a graduate degree.

Since forestry is concerned primarily in the production, use and maintenance of wealth from forest soils, it must rest on a sound economic foundation. Constructive and intelligent methods of forest management will be employed only if they pay directly in dollars and cents or indirectly in social services such as the regulation of stream flow, the development of recreational facilities in general or the stabilization of community life in forest regions. The purpose of forestry is to obtain from forest lands and their products the greatest economic, industrial and human service.

Over eighty per cent of our forest area is owned by the Crown, that is, it is in public ownership; it belongs to the people of Canada. Are the best interests of Canada being served when three million acres, on the average, are burned each year? This area is equivalent to a strip of land a mile wide from Halifax to Vancouver and one-third of the way back again.

The number of annual fires on a ten-year average is 5,700. Taking the average fire season as one hundred and fifty days, this means that about forty fires are being started each day during the season. Granting the fires start during the day time, a new fire occurs somewhere in Canada each twenty minutes during the daylight hours of the fire season. The cost of fighting fires, the value of timber, young growth and property destroyed amounts in round numbers to ten million dollars a year. In Ontario, on a ten-year average, about half a million acres burn each year. If these were grouped in one block they would cover more than twenty ordinary sized townships.

Are the best economic interests of Ontario being served in the long run by maintaining a system of cutting trees that makes little or no provision for a future crop on the cut over areas? This system has in the past left behind it thousands of square miles of barren and semi-barren lands and depopulated once prosperous saw-milling towns, as for example in the former pine districts of central Ontario.

It is the object of forestry to create forest conditions so that such economic waste would not occur. It is certainly a great problem in this country to prevent such waste by the restoration of normal forest conditions, but it must be resolutely faced and acted upon if the full economic and industrial possibilities of our forest heritage are to be realized.

But the chief purpose of forestry goes beyond the mere restoration of previous forest conditions. What would be the status of agriculture today, if man had continued to be satisfied with the fruits and grains which nature gave him? Nature is satisfied if she covers the ground with trees, whether or not they are of any economic use to man. Thus there are forested areas that are of no direct value to man, although they may have considerable indirect value for watershed protection and cover for game and furbearing animals. The commercial forests themselves are usually uneconomical mixtures. Valueless trees grow side by side with valuable trees. Of the valuable kinds the crooked and decrepit are mixed with the straight and healthy trees. The result is that our forests as nature gives them are low in commercial wood production. For example, the average cut of spruce pulpwood in eastern Canada is about eight cords per acre, based on the area actually worked over for logs leaving out the barren or burned areas. Further, it has taken eighty to one hundred years to produce that eight cords on the average acre. This small yield is not all the wood produced on the average acre during this long period. There may be twice as much wood, or more, but much of it is non-commercial because of kind or quality.

Such low yields on good forest soils near markets are uneconomic.

Just as agriculture has greatly increased the quantity and improved the quality of the crop on farm soils, so also

Sand Dunes Covering Fences.

the science of forestry when given opportunity increases the quantity and improves the quality of the crop on forest soils. An essential difference in the two cases is the time element; it takes longer to bring a crop of trees to commercial maturity than the ordinary farm crop. This then is the chief object and practice of forestry in those countries where it gets a real chance.

### European Methods

There are many European countries where forestry gets a chance to demonstrate what it can do, as for example, in Denmark, Norway, Sweden and Finland. The most impressive thing to a Canadian travelling through those countries is the care and thought put into the propagation and management of the forests. Each stage in their development is the result of careful planning and direction. They leave an impression of well being, tall straight trees with long clean bodies, no crooked trees, no dead or dying trees. There is no devastation by lumbering and no large areas of waste land, at least in the commercial forest regions.

The original charter of a large mining company in a town in central Sweden contains the grant of a large area of forest to furnish charcoal for smelting the copper and iron ore from the mines, and was granted in 1288. When the use of charcoal declined with the introduction of electrical power smelting, the company went into the lumbering and pulp and paper business. The forest holdings of the company have been cut over for the past one hundred and fifty years under the direction of foresters and the land supports more timber per acre today than ever before.

The principle at the base of practically all the forest treatment in the Scandinavian countries is the gradual opening up of the forest. This is accomplished by clean cutting in patches and narrow strips or by a series of thinnings. The latter seems to be in most general use. The thinning begins as soon as the product can be sold and continues at intervals of five years or so over a period of twenty or thirty years. In the later stages the thinnings are heavier, that is, a larger proportion of the trees is removed.

These heavier thinnings let in more light and heat and thus stimulate the food manufacturing processes in the soil. This makes conditions favourable for the natural regeneration of the forest, so a new forest begins to develop under the protection of the older trees. In the last stages of the system there may be only ten or a dozen or even less seed-trees per acre. They do not blow down in their isolated positions, because the protecting trees around them have been removed gradually through a period of twenty or thirty years, sometimes longer. (In our system of cutting pulpwood, if a few scattered seed-trees are left accidentally or otherwise, they are soon overthrown, for there is no attempt to train them gradually to wind resistance.) In time the scattered seed-trees usually cover the ground with young trees, and then the mother trees when no longer needed are removed. In course of time the thinning cycle begins again in the new forest.

In the early stages the thinnings are used for fuelwood and in Sweden particularly for charcoal wood as well; in the later stages for pulpwood and saw logs. The thinnings remove the decrepit and backward trees to give more room for the straight and rapidly growing trees. That is the reason the forests give the impression of vigour and well being. With each thinning the remaining trees have more room for crown expansion and they have fewer competitors for the food materials in the soil; thus they grow faster and, being well pruned when they were growing close together in their earlier stages, they make a better quality of wood.

The result of such treatment is that the well managed pulpwood forests yield much more per acre than our uncared for forests. Scandinavian forests on the best soils yield about a cord of wood per acre for each year of their life, so if the trees are seventy to eighty years old when the final cutting takes place they have yielded since the first cutting seventy or eighty cords per acre. On the medium soils the yield is about one half and on the poorer soils about one fifth this amount. It is a fair statement to say that the commercial forests of Sweden yield forty to fifty cords per acre during the rotation, or in other words five or six times more than our pulpwood forests produce on the average during the same period of time. There are extensive pulpwood areas in eastern Canada that yield no more than five or six cords of commercial wood per acre.

This shows what might be accomplished with our pulpwood forests if regarded not as mines to be exploited as soon as possible but as crops to be continuously reproduced.

In normal times Ontario cuts about a million cords of pulpwood annually. In the lowest of depression years, the production fell to half that amount, but owing to improved business conditions and the energy of the present government it is probable that the amount cut during the present season will equal or surpass the normal of one million cords. Taking the production on the average acre as eight cords, about 125,000 acres are cut over to produce a million cords of pulpwood each year. If these pulpwood forests were as fully stocked and well treated as those in Sweden, 25,000 acres—an area a little larger than that of an ordinary sized township—would furnish an equal amount of pulpwood during the rotation period. Since the rotation in Sweden is eighty years, eighty townships would suffice to furnish perpetually one million cords of pulpwood each year. According to the latest governmental report, the pulpwood concessions in the province aggregated some 53,000 square miles of forest land or the equivalent of more than 1,400 townships in area.

It would of course take a long time to put our forests into such highly productive condition as those of the Scandinavian countries, but would it not be worth while? Other things being equal, it would greatly cheapen the cost of logs at the mill, because one acre during the rotation period would yield an amount of wood equal to five acres of our unmanaged forests. We must keep down the manufacturing costs of wood pulp and newsprint if we are to compete in the world markets. In normal years the tendency has been the other way, that is towards increasing costs, not entirely but largely due to the fact that the wood supplies are receding farther and farther from the mills. Every mile increase in the distance of supplies from the mill, increases our disadvantage in the export markets. Practically the only alternative left to us is to treat our forests in such a way as to greatly increase the production of wood per acre.

**Remains of White Pine Forest with Young Plantation in Background.**

There is another great advantage in the Scandinavian methods, namely the increased efficiency of labour. The woods workers in Sweden, for example, have permanent jobs and live on little farms along the streams in the forest. For the most part, they can return to their homes at night; in fact timber cutting and logging is a trade handed down from father to son. The men make a good living and they are contented. Labour disturbances are very unusual.

Contrast these conditions with those in the pulpwood forests of northern Ontario, where usually three crews are in evidence, one going in, one going out and another actually at work in the woods. A company needing only 500 men for timber cutting may have 1,500 different men on its pay roll during the cutting season. Such a great labour turn-over can only result in inefficiency and high logging costs.

In reply to statements urging us to look to Scandinavian countries for guidance in the management of our forests, it is said that climatic, labour, and market conditions are so different that no just comparisons can be made, but is this true? The climatic conditions of central Sweden, for example, where the commercial pulpwood forests are located, are practically the same as those of northern Ontario. The soils appear to be poorer. It costs the operator about the same amount per cord to get his logs to the mill. The labourers in the mill and in the woods get about the same monthly wage. The tax burden on the industry is certainly as great as in Ontario. The companies pay a property tax to the municipalities in which their timberlands are located; they pay a graded income tax; they contribute towards sickness insurance, old age pensions, and in some cases to unemployment insurance. The employees in the mills in some of the countries draw a two weeks holiday with full pay, or a month's holiday with half pay.

Even with all these charges on the industry, the pulp and paper companies do not feel that they are compelled to cut every available stick of pulpwood on a given area at one time in order to make a reasonable profit. They wish to establish a permanent business, so they handle their forests in such a manner as to make them continuously productive, that is the amount of the annual cut does not exceed the amount of annual growth. It should be noted, however, that this point of view has been brought about gradually under governmental leadership during the past thirty or forty years. The government through the work of its foresters first demonstrated that the forests on Crown lands could be managed on the basis of sustained yield with profit. Then laws were passed which stated in effect that a lumberman or a woodlot owner may cut in any manner he pleases on his own lands, but he must re-establish the crop. There must be no idle forest soils within the commercial forest region. If the owner cuts an area clean he must re-establish the crop by planting seedlings or sowing seeds. If he has not done this within three years, the state does it for him and sends him the bill. If he refuses to pay, the bill is sent to the tax collector. There is no escape from the obligation. As already stated, however, most of the operators get the new crop as a result of their logging operations through periodic thinnings. Here again the state foresters first demonstrated that this method was profitable.

A trade situation follows from the high yield condition of the Scandinavian forests that should be of great concern to every Canadian citizen. The export of chemical pulp from these countries to the United States mills to be converted by them into various paper and cellulose products is steadily increasing from year to year. Thousands of tons of this material pass by Toronto's front door, up the St. Lawrence and over the lakes to mills in Michigan and Wisconsin. Every ton thus going to the United States mills reduces by so much our export market of chemical pulp. The United States mills buy this material because it can be laid down at the United States lake ports and seaports at a smaller price than from our mills only a few hundred miles away. The principal reason for this is that the Scandinavian countries cut five cords where we cut only one on an equal area.

**Pine Seedbeds, showing Protective Shades and Overhead Watering.**

These facts are the basis of the argument that the productiveness of our pulpwood lands must be increased if we are to remain much longer as a competitor in the world markets.

But, we are told, why worry, we have such extensive forested areas that our supplies are inexhaustible. Is this correct, from an economic standpoint? Stands of timber located so far from the mills that they cannot be profitably utilized should not enter into the calculation, so that estimates of our timber supplies should not be accepted without careful analysis. So many modifying influences surround the problem that most predictions as to the limit of pulpwood or sawlog supplies are mere guesses based on insufficient data; only a few are well considered estimates based upon available factual data.

Three-year-old Spruce Beds ready for Planting.

### Forest Depletion

The usual method of procedure is to take the estimate of the total standing merchantable timber in the country and divide it by the annual depletion. The annual depletion by logging is known and the depletion by fire can be fairly well estimated. Using these data, it is found that in the country as a whole we have only about forty years supply of saw-timber and perhaps a little more than one hundred years supply of spruce and balsam pulpwood. More than one-half of the estimated saw-timber is located in British Columbia. This estimate is based on the timber of merchantable size within the territory where logging is profitable under normal economic conditions, but includes within that territory many isolated areas that because of size or geographic location cannot be profitably utilized.

On the debit side of this estimate are other factors of depletion for which data are insufficient. These are insect pests, fungous diseases and wind storms. It is known that the annual depletion from these causes is very great. For example about fifty years ago an infestation of the larch sawfly began on the Atlantic coast and eventually reached the Pacific, killing practically all the larch trees on the way. About twenty years ago an epidemic of spruce budworm is estimated to have killed fifty years supply of pulpwood in Quebec and the maritime provinces. Within the past few years a spruce sawfly, more thorough and destructive in his work than any of the previous pests, started on a rampage in lower Quebec and is spreading rapidly westward. The Federal Government is making heroic attempts to check this latest epidemic by the introduction of parasites from Europe.

The depletion of standing timber values by fungous diseases is much less spectacular than that by insects and usually passes unnoticed except by the trained observer. About a year ago the specialist at Ottawa in charge of the study of forest-tree diseases stated that in his opinion the depletion of timber by fungous diseases each year was at least as great as that by logging.

The attrition by the wind is going on in the forest constantly. Much of this is a normal process but there is no doubt that it has been much increased by the opening up of the forests by lumbering operations and by fire.

Here then are three very important factors of depletion which we have as yet no method of measuring, although no reliable estimate of the duration of forest supplies can be made without taking them into consideration.

On the credit side of the ledger there are other non-assessable factors which are favourable, for instance, the enormous areas of young growth which cover more than four hundred thousand square miles in the Dominion as a whole.

In general there are three classes of these young growth areas. Some of them have been burned over and over again until all the softwood trees have been killed and they are now covered with inferior hardwoods. These areas will probably not enter into the future supply of spruce pulpwood, at least not for a hundred years, unless they are planted. Another class, not so severely burned, contains scattered young softwood trees but probably not enough to make such lands commercially valuable in the future unless they are reinforced by planting. From this type of young growth lands there are all transitions up to well stocked stands of young pine and spruce of great potential value.

Thus about one half of the accessible and productive forest area of the Dominion is covered by young growth stands not yet of commercial size; this is a condition chiefly due to forest fires. When the present commercial stands are cut over, resort must be had to the now young growth areas for future supplies of pulpwood and sawlogs. What can be expected from them? How much cordage are they building up for future use? This must be known before we can make any reliable estimate of the duration of our forest supplies. Before the depression overtook us, the Dominion Government and several provincial governments, including our own, began investigations to determine the growth and yield on second growth areas, but this work was seriously curtailed or wiped out in the name of economy. In Ontario it was completely abandoned. Such investigations should be resumed when budgets are balanced, because there is urgent need for reliable estimates of what is happening on one-half of the accessible forest lands of Canada.

Having pointed out some of the biological factors of depletion and accretion in the forest, and our inability to evaluate them because of insufficient data, we may pass to some of the economic factors of the problem of the duration of supplies. On their present basis, neither the sawmilling industry nor the pulp and paper industry could exist without the export market. Nearly one half of the lumber and more than four-fifths of the pulpwood products are exported. This means that the price of wood pulp, newsprint and lumber is controlled by the foreign markets. Every drop in the price of newsprint contracts the zone around a mill where operations can be profitably carried on. The price of newsprint is about sixty per cent that of ten years ago, and so the available supply of pulpwood has decreased very considerably in the past ten years on areas where not a stick may have been cut or no fire or insect depredation may have occurred.

Railway freight rates are another important factor in the commercial availability of pulpwood supplies for a given mill. There are two mills in this province whose distances from Toronto do not differ by twenty-five miles, yet one pays $6.80 and the other $3.60 per ton on newsprint by rail transportation to this city. This is due to the competition of the cheaper water transport in case of the lower rate. These two companies presumably pay the same amount per cord to the government for their wood. It takes about a cord of wood to make a ton of newsprint, so one company has an advantage of $3.20 per ton of newsprint over the other, on the assumption of equally efficient management. Therefore the company most favourably situated in respect to freight rates can go farther from the mill for its wood, and its commercially available supplies are the larger. The less favourably located company may have twice as much pulpwood on its limits but this is not reflected in the economic duration of its supplies.

There are of course other economic conditions, such as the cost of labour and materials, which enter into the problem of the available supply of timber.

**Plantation of Pine on Blow-sand Area.**

From the above considerations it is evident that any statement as to the length of time our timber supplies will last is entirely meaningless unless the factors of accretion, depletion and economics have been taken into consideration. A statement for example that a province has millions of cords of pulpwood in reserve, without any modification as to their commercial availability, is not only meaningless but misleading if it gives the public, the owners of the forest, a false feeling of security in regard to their property.

### The Fire Hazard

In regard to forest conservation one's first thought is naturally the destruction of the forests by fire and its prevention. Fire is undoubtedly the arch enemy of the forest. The forester's conception of the damage done by forest fires is not the same as that of the public. A newspaper will report that such and such a fire did no particular damage because it killed no standing timber. The forester knows that the most destructive fires are those that burn the young growth areas, from which our future supplies, if we have them, must come. Frequently, the first fire in standing timber does not do much damage, for the commercial trees killed are usually salvaged during the next cutting season and the natural regeneration following the fire is not seriously interfered with. The same holds true of the first fire on cut-over lands. In fact the best stands of young growth pine and spruce are to be found on areas that have been burned once and once only. The hope of the future lies in such stands, but unfortunately most stands of this kind are not allowed to grow up, because they are burned the second time, the third time; some of them are burned over and over again. The public does not realize that each year thousands of acres of potential forest lands are being transferred to the barren and semi-barren class through the agency of repeated forest fires, to remain in this condition for generations of men, unless restocked with commercial species artificially by planting.

Other disastrous effects of repeated forest fires also are not generally realized. They destroy the vegetable binding material of the soil, which with the next heavy rain starts on its way to the sea. Repeated forest fires prevent the accumulation of vegetable matter on the forest floor, which acts as a storage reservoir for rain water. Without this moist blanket, surface drainage is increased, the water flows from the watersheds in a shorter period of time; hence high flood stages of the streams in the spring and after the heavy fall rains, and also low stream stages in the summer. The economic losses resulting from the disrupted regime of our streams would more than pay the cost of a more effective fire protection.

The forest fire problem in its various aspects is so serious in terms of future forest supplies and the disordered condition of streamflow, that it should be given serious thought by all intelligent and patriotic citizens. Is this problem not being attacked at the wrong end? The greater portion of our energy and money is being spent in extinguishing fires after they have started. Would it not be much more logical and businesslike to spend the greater part in forest fire prevention, that is, in educating the people, because eighty or ninety per cent of all forest fires are due to human carelessness.

Most of the forest fires in northern Ontario are caused by tourists, campers, fishermen and the like. Psychologists tell us that it is very difficult to change the attitude of mind of an adult, so it would be well not to spend too much money in the attempt to educate carelessness out of the mind of the average tourist. It would be more effective to compel him to take a licensed guide with him to look after his camp fires and his cigarette stubs. It is probable that most of the tourists would not mind the extra expense and the plan would give at least summer employment to men who need work. There is already a law that gives the government power to close a forest to travel in time of danger, but it is difficult to enforce and in practice has not worked out well. It would be more effective and more profitable to the community to allow the tourist to enter the forest but furnish him with a guardian—at his own expense.

**Red or Norway Pine Plantation, Twenty Years Old. Trees 4 to 8 inches Diameter.**

The tourist-generated fire far in the wilderness is the most difficult to put out and easily gets out of hand, destroying extensive areas of forest. This class of fire should be subjected to more effective measures of prevention than at present exist, this to be accomplished through closer supervision of the deep woods traveller.

The most effective way of educating people into forest fire consciousness is to concentrate on the young people, whose minds are receptive. If the rising generation, the future frequenters of the forest, can be educated into a proper attitude towards forest fires our problem would be practically solved. This method is very successfully employed in the northern European countries and is being used with measurable success in certain states in the country to the south of us. Provision might well be made for giving illustrated lectures on fire protection in every high school in the province. These might be supplemented by simply written pamphlets on the subject to be used as collateral reading in the schools. The boy scout organizations are doing good work along these lines, but a relatively small proportion of the school population becomes boy scouts and we can reach the largest number most effectively by concentrating on the schools.

It seems, then, entirely logical and business-like to spend more money and energy in removing as far as possible the principal cause of forest fires, human carelessness. Until this is done in a well planned thoroughly organized statesmanlike manner, the cost of fire fighting in Ontario will increase until it becomes a serious burden upon the taxpayer. This statement is based upon the well known fact that the hazards are increasing in northern Ontario, due to the increasing tourist traffic and the greater accumulation of slash in the forest with the increasing lumber activities.

### Utilization and Marketing

Next take another problem which has an important bearing on the intelligent treatment of the forests for the purpose of maintaining Ontario's position in the world markets. It has been mentioned that one reason why the Scandinavian countries can keep their forests on a sustained yield basis is because they are able to utilize profitably the smaller trees removed by thinning, this material being used chiefly for fuelwood. These countries are short of coal; they have to import most of it, and their governments make it their business to discourage the sending of money out of the country to buy coal. They set a good example by using wood fuel in all the public buildings outside the few larger coastal cities. They have devised heat conserving furnaces for this purpose. The stoves in the private houses, and there is one in every room downstairs, do their work effectively and are very economical in the use of wood.

We could do a great deal more than at present towards using more of the low grade material for fuel. Good roads and automobile trucks are bringing the supplies constantly nearer the consumer. Cases are already in evidence where fuelwood has been hauled profitably for a distance of fifty miles or more. Greater use of wood for fuel in the country towns and villages would help reduce that twenty-five million dollars sent from Ontario each year, largely to the United States, to purchase coal for domestic heating purposes.

Another closely related problem lies in making possible a greater use of the so-called inferior hardwoods that are quite generally mixed with the more valuable soft woods throughout our forested areas. This could be done by developing minor wood using industries in the smaller towns, manufacturing furniture, tool handles, shoe pegs and perhaps a hundred and one other wood articles in common use now imported, in most part from the United States. The establishment of small woodenware industries would stabilize the working population of the small towns and increase the productivity of the forests.

A serious problem has arisen in marketing our sawmilling products, brought about by the constantly increasing use of substitutes for wood in building. The sawmilling industry, including all the factories that use wood as a whole or in part, produces more wealth annually for this province than the pulp and paper industry. This increasing use of substitutes for wood has been brought about largely by high powered advertising, although as a matter of fact wood is more serviceable in many positions than the substitutes now used.

To maintain our present position in relation to the world markets (to say nothing of improving it), the only way is to produce a better quality of product at the same price or the same quality at a cheaper price than our competitors. The manufacture of pulp and paper products however is so efficiently carried on, that there is probably not much more to be accomplished towards improving the quality of these products. There may however be a wider field for improvement of the quality of the product among many of the sawmilling establishments. The more progressive operators are conscious of this and are making strenuous efforts to remedy the situation.

On the whole then the problem is to put our products into the export markets at a cheaper price than our competitors, even though the cost of logs delivered at the mills is constantly increasing with the increasing distance to the supply, and there is increasing expenditure on higher wages, better housing and improved social services for the labourers in the woods.

The only solution seems to be an increase in the yield per acre. Other countries have done similar things with their forests. It is humiliating to acknowledge that we have less intelligence and less foresight.

The wood nearest the mill is the cheapest to convert into newsprint and pulp and as a general statement the areas nearest the mills have been the most completely wrecked from the standpoint of their continuous wood producing capacity. The first logical step is to restore these areas to productivity. In most cases this would mean planting.

The cheapest pulpwood products today are manufactured where the companies have the advantage of relatively low water transportation cost and this in all probability will be a more pronounced advantage in the future. Therefore the most profitable planting programme would consist in planting pulpwood species on the waste Crown land areas adjacent to the Great Lakes and the St. Lawrence river; there are hundreds of square miles of such lands available now lying practically idle so far as the growing of valuable softwood trees is concerned.

We are compelled to plant because we have abused our forest lands. The planting of large areas is an acknowledgement of our failure to understand nature's recuperative forces in the forest and to make them work for us. It seems illogical and unbusinesslike in our cutting operations to continue to employ methods that only lead to forest sterility so far as the next generation is concerned. Therefore the next step in the process of increasing the productiveness of our forested areas in order to maintain our position in the world markets is gradually to bring about a change in cutting methods, or in other words to treat the forest in such a manner that nature will produce the next crop for us practically free of charge. In this way no cutover lands would lie idle for long periods of time; they would be covered all the time with on-coming crops.

Emphasis has been placed all through this paper on the necessities of the pulp and paper industry if it is to be maintained through a long period of years, but all that has been said applies as well to the sawmilling industry.

The programme outlined is a large one, but the author believes that it must be carried out if our wood using industry, the third largest wealth producer in the province, is to be maintained in the markets of the world.

Note: The illustrations appearing with this paper are reproduced by courtesy of the Department of Lands and Forests, Province of Ontario

# Recent Developments in European Railroad Motive Power

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**SUMMARY.—This survey of European practice gives particulars of present-day locomotive performance, discussing the successful modernization of steam locomotives in France, new developments in Great Britain and Germany, and the present situation as regards Diesel railway equipment in European countries.**

## INTRODUCTION

Motive power, and more particularly the steam locomotive, was responsible for the advent of the railway. Iron rails were used in England in the middle of the 18th century (1767), but the railway, as the modern means of mass transportation, had to wait until a successful unit of motive power, Stephenson's "Rocket," came into existence, one hundred and seven years ago. Then the railways sprang up, first in England and in the United States, and shortly afterwards, in every civilized country of the world.

During these one hundred and seven years railroad motive power made tremendous strides in its development and, accordingly, influenced the development of the railroad. The only thing left unchanged, although not without some exceptions, is the standard gauge, or, as it is sometimes called in Europe, the Stephenson gauge. Also, almost unchanged remained the clearance outline of the rolling stock and the bore of the tunnels. Everything else progressed, depending on the development of motive power, and more particularly, on that of the steam locomotive, as its progenitor. The progress in the art of rolling rails, and in rail metallurgy, is the result of the demand of motive power as the weight and speed of the locomotives went up. The same is true for railway signalling, which has made such marvellous progress in the last two or three decades, for automatic brakes, which have kept pace with the increase in weight and speed of our trains, and for every line of railroad engineering—all depending upon the progress which is being made by railroad motive power in general, and by the steam locomotive in particular.

The motive power engineer who is responsible for the up-to-dateness of his locomotive, must watch the progress in stationary power plants, steam boilers and engines, turbines, condensers, Diesel engines, transmissions, etc. Furthermore, he has to be familiar with the progressive ideas and attempts of his fellow engineers in other countries. Practice in Europe, the cradle of the steam locomotive, will repay his careful consideration. The author has been fortunate in being entrusted with the task of making frequent trips to Europe and keeping in touch with European developments by personal contact with railroad motive power and equipment supply engineers, and welcomes the opportunity to share part of his experience and some of his views with the members of this Institute.

## Speed and Power

The present trend in Europe, as also in this country, is towards increased speed. Freight and passenger traffic are being accelerated, not only in England, France and Germany, but also in smaller European countries. There are now in Europe a number of trains with average schedule speeds of 75-80 m.p.h., whereas in 1932 the "Cheltenham Flyer" of the Great Western Railway in England, with an average speed of 71.4 m.p.h., was the only fast train in Europe.

France and England have had a long-established reputation for the fastest trains in Europe; but since 1931 Germany has made enormous strides in this respect. Five years ago Germany had only one train from Breslau to Königszelt, with an average speed of 58.2 m.p.h., over a distance of 30.1 miles, while now there are 157 daily trains at that speed and over, with a total mileage of 11,000, or about thirty-six times as large. Of these trains, ninety-one, covering an aggregate daily mileage of 6,276, are running with speeds of 60 m.p.h. and over; of these latter trains, some are running with speeds over 62 m.p.h. (mileage 5,118); of these again, some with still higher speeds of over 64 m.p.h. (mileage 3,921); still others at speeds over 66 m.p.h. (mileage 3,641); further, with still higher speeds of 68 m.p.h. (3,000 miles), and twenty-nine trains with speeds of 70 m.p.h. and over. These latter trains alone have an aggregate daily mileage of 2,287.*

One of the new flyers, "Der Fliegende Kölner," covers the distance from Berlin to Cologne, 359.5 miles, in four hours and fifty-seven minutes (five stops), with an average speed of 72.6 m.p.h. Another flyer, from Berlin to Beuthen on the eastern border, covers the distance of 322.8 miles in four hours and thirty-four minutes (seven stops), with an average speed of 70.7 m.p.h.

The train "Flying Kölner" referred to above, is of the Diesel-electric type, first introduced in 1932 between Berlin and Hamburg and known as the "Flying Hamburger," with an average speed of 77.4 m.p.h. It makes the trip from Berlin to Hamburg (178.1 miles) in one hundred and thirty-eight minutes. The "Flying Kölner" has five stops between Berlin and Cologne and its average speed is only 72.6 m.p.h. in one direction and 69.8 in the other, but on its way to Cologne it makes a non-stop run from Berlin to Hannover, a distance of 157.8 miles, in one hundred and fifteen minutes, with an average start-to-stop speed of 82.3 m.p.h. This is the highest start-to-stop speed to be found in any railroad timetable, except that of the "Super-Chief" on the Santa Fe, which covers the distance between La Junta and Dodge City, 202.4 miles, in one hundred and forty-five minutes at an average start-to-stop speed of 83.7 m.p.h. There are now in Germany more than a dozen trains of this kind making regular runs daily, sometimes twice daily, between the principal cities of Germany: Berlin, Cologne, Leipzig, Frankfurt, Hamburg, Bremen, Stuttgart, Nuremberg and Munich. The longer distances are usually covered daily by a pair of trains of which one leaves at one end about 6 a.m. and arrives at the other end around noon, while another pair covers the same service from about 6 p.m. until midnight. Thus, a business man can go to a city at a distance of 300-350 miles, spend half a day there, and return home the same day.

Steam power takes care of heavy long-distance trains. There are now in Germany thirty-three daily steam trains with average speeds from 60.0 to 68.9 m.p.h. and thirteen electric trains with speeds in the same range; some of these are high-speed long non-stop runs, the longest high-speed run being from Leipzig to Nuremberg, on which a steam locomotive hauls a heavy train over a distance of 200.1 miles without stop, with an average speed of 58.9 m.p.h.

*These and the following figures, given in this chapter on speed and mileages, including those in Table I, have been taken from Cecil J. Allen's articles on speeds of European trains, which appeared in the Railway Gazette for 1936 (issues of January 31, February 21, March 6, March 27 and June 19). The figures and the table are reproduced here with this periodical's permission, for which the author takes this opportunity to express his sincerest thanks.

High-speed development in France followed a different path. The French railcar, driven by a gasoline engine and called "automotrice," was one of the first to appear in Europe. Now it is called "autorail" and is mostly driven by a Diesel engine. On the 1st of January, 1935, Germany had one hundred and sixty-eight railcars in service and two hundred and twelve under construction, a total of three hundred and eighty railcars compared with four hundred and sixty-three in France. The majority were built with Diesel engines, but the Bugatti and Michelin cars have gasoline motors. Very few have electric transmission. They have either mechanical, or mechanical with hydraulic drive.

The development of the German "Flying Hamburger" had a limited influence on the French high-speed development. Only two three-unit Diesel-electric trains were in service in France early in 1936, although many more trains of this type were under construction. At present at least four high-speed trains are already in operation. The average speed of the first two trains between Amiens and Arras on the Nord Railway is 68.3 m.p.h., but only a slightly lesser speed is being made by steam traction on the non-stop Paris-Brussels express run, covering a distance of 193.1 miles in exactly three hours (average speed 64.4 m.p.h.).

The Bugatti light-weight gasoline cars are used on the Etat, between Paris and Hâvre, on a distance of 141.5 miles, with one stop at Rouen. The average speed is 70.8 m.p.h.· The start-to-stop speed on the two laps of the journey, excluding the stop at Rouen, is 70.2 and 73.2 m.p.h. Bugatti cars are also used on the Est and Paris-Lyon-Méditerranée lines. Their start-to-stop speeds on these roads are about 70 m.p.h. It is interesting to note that the speed limit on French roads, is 87 m.p.h. for the Bugatti cars and only 75 m.p.h. for steam locomotives. Very often the service demands substituting steam locomotives for Bugatti cars. The average speed then drops to only 65 m.p.h.

The Paris-Orléans-Midi line has the distinction of operating the fastest steam trains on the continent of Europe: the distance between Poitiers and Angoulême, 70.2 miles, is covered by the Sud Express in exactly one hour—and this notwithstanding the speed limit of 75 m.p.h. The same road can boast other speed records of steam propulsion, very remarkable ones, considering the limitations imposed by grades, curves and slow-downs; and finally, the P.O.-Midi was, until recently, remarkable as the only French railroad without internal combustion railcars for very high speed; it was able to take care of all its traffic by steam power.

The French roads have quite a number of non-stop runs over 100 miles in length and several of the longest runs on the continent, up to 216.7 miles. The locomotives have no water pick-up, the tenders are not exceptionally large; the engines, therefore, are bound to be economical.

Great Britain is mainly a steam traction country. There are on the British railroads fifty-two daily steam runs with start-to-stop speeds of 60 m.p.h. and over. The mileage of these runs is 5,371. No Diesel or electric train runs belong to this category. In this respect Great Britain differs essentially from both Germany and France, where Diesel railcars and trains are in vogue. A partial explanation of this fact can be found in Sir Nigel Gresley's last presidential address before the Institution of Mechanical Engineers, on October 23rd, 1936, in London. He stated that after a trip in 1934 on the "Flying Hamburger" from Berlin to Hamburg and back, he approached the makers of that train, supplied them with data on the grades, curves and speed restrictions of the London and North Eastern Railway, and got from them a proposition for a Diesel-electric train weighing 115 long tons, to run from King's Cross (London) to Newcastle, 268 miles. They offered to cover the distance in four hours seventeen minutes going up, and four hours fifteen and a half minutes coming down, which the London and North Eastern could easily accomplish with steam power. To prove that, they ran a train on March 5th, 1935, weighing 253 tons and hauled by a regular seven-year old Pacific type steam locomotive at an average speed of 67.05 m.p.h., covering the distance from London to Newcastle in four hours, and thus bettering the time offered by the German Diesel-electric train builders for the London and North Eastern local conditions. The decision to build a steam train, the "Silver Jubilee," was then reached.

This train, which has been running now for over a year between London and Newcastle in four hours, with one stop at Darlington, makes the regular trip from King's Cross to Darlington at an average speed of 70.4 m.p.h. On its down journey the distance between Hatfield and Selby, 156.7 miles, is covered in one hundred and twenty-five and a half minutes at a speed of 74.9, almost 75 m.p.h., from pass to pass, but not from start to stop.

Only one steam train in Great Britain, the "Cheltenham Flyer" on the Great Western, makes slightly better speed than the "Silver Jubilee." It covers 77.3 miles in sixty-five minutes, with an average speed of 71.4 m.p.h. from start to stop. Therefore, the distinction of running the fastest steam trains in Europe still belongs to Great Britain.

The above figures, which should give a brief idea of the present trend in the progress of speed on principal European railroads, as it has established itself in 1936, are summarized in Table I, in which comparative figures are also given for the United States and Canada.

In order to achieve these remarkable results, not only new designs and improvements of the power plants became necessary, but new ideas in the construction of the equipment had to be adopted. This led to the practice of lightening both locomotive and cars, and established a tendency to what may be called "concentration of power." With the increase in speed the power per unit of weight had to

Table I
Aggregate Daily High-Speed Mileages, 1935

| Country | 60 m.p.h. and over | | | 64 m.p.h. and over | | | 70 m.p.h. and over | | |
|---|---|---|---|---|---|---|---|---|---|
| | Steam mileage | Diesel mileage | Electric mileage | Steam mileage | Diesel mileage | Electric mileage | Steam mileage | Diesel mileage | Electric mileage |
| Germany | 3,101 | 2,992 | 633 | 659 | 2,973 | 289 | ...... | 2,287 | ...... |
| France | 4,855 | 2,232 | 325 | 662 | 1,655 | 139 | 70 | 764 | ...... |
| Great Britain | 5,371 | ...... | ...... | 996 | ...... | ...... | 542 | ...... | ...... |
| U.S.A. | 9,469 | 2,339 | 7,471 | 3,351 | 1,801 | 1,551 | 669 | 232 | 24 |
| Canada | 50 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |

Table II
Specific Power Factors of Steam and Diesel Locomotives and Trains

| Item | Locomotives | Cylinder or b.h.p. | Rail h.p. | Weight, Half-working Order, tons | Specific Power Factor |
|---|---|---|---|---|---|
| | *Steam Locomotives* | | | | |
| 1 | Reichsbahn 4-6-2, 4-cyl., comp. superheat, No. 02010 | 2230 | 2007 | 169.4 | 11.9 |
| 2 | P.O.-Midi 4-6-2, 4-cyl., comp. superheat, No. 3579 (1912) | 1873 | 1586 | 152.0 | 10.4 |
| 3 | Rebuilt P.O.-Midi 4-6-2, 4-cyl., comp. superheat, No. 231-726 (1934) | .... | 3500 | 182.0 | 19.2 |
| 4 | Nord 2-8-2, tank with Cossart piston valves (1935) | .... | 2330 | 126.1 | 18.4 |
| 5 | P.L.M. rebuilt 4-6-2 locos., 4-cyl., superheat (1932) | .... | 3000 | 174.0 | 17.3 |
| 6 | Nord 4-6-4, multiple reciprocating engines, individual drive (under construction) | .... | 2400 | 184.6 | 13.2 |
| | *Steam Turbine Locomotives* | | | | |
| 11 | L.M.S., 4-6-2, direct drive, gear transmission | .... | 2500 | 171.0 | 14.7 |
| 12 | U.P., 4-6-6-4 + 4-6-6-4, electric transmission (under construction) | 5000 | 3750 | 480.0 | 7.3 |
| 13 | P.L.M.-Creusot, 4-6-4 locomotive, direct drive (under construction) | 2625 | 2460 | 191.6 | 12.8 |
| | *Diesel Locomotives and Trains* | | | | |
| 21 | 600 b.h.p. switching, U.S.A.* | 600 | 450 | 68–110 | 4.3–6.7 |
| 22 | Canadian National 4-8-2 + 2-8-4* | 2660 | 1995 | 162.5 | 6.1 |
| 23 | U.S.S.R., 4-8-2 + 2-8-4* | 2400 | 1800 | 265.0 | 6.8 |
| 24 | Busch-Sulzer, 1-B + B-1* | 2000 | 1500 | 173.0 | 8.5 |
| 25 | Ingersoll-Rand, Illinois Central* | 1800 | 1350 | 130.0 | 10.3 |
| 26 | B-B + B-B, Santa Fe* | 3600 | 2700 | 241.0 | 11.2 |
| 27 | P.L.M., 4,000 h.p. (under construction)* | 4000 | 3000 | 246.4 | 12.2 |
| 28 | "Flying Hamburger," Diesel-hydraulic, 3 units | 1200 | 900 | 77.0 | 11.7 |
| 29 | "City of San Francisco" (2 locomotive units)* | 2400 | 1800 | 195.7 | 9.2 |
| 30 | Denver "Zephyr" (2 locomotive units)* | 3000 | 2250 | 213.0 | 10.5 |

*With electric transmission.

go up. When further the Diesel engine proved its advantage as regards thermal efficiency, there was a great temptation to adopt high-speed Diesel-electric trains. However, the limitation of the Diesel engine, even the high-speed Diesel, with respect to its power-weight ratio, soon became apparent, and, therefore, if the power plant was heavy, the chassis of the vehicle had to be light. Thus, new metals, like aluminum, high tensile or stainless steel, and new methods of construction, like welding, had to be employed. This led to the light-weight Diesel-electric train, introduced first in Germany, and then in the United States and in other European countries. If the Diesel could not meet the power of the steam locomotive, it was necessary to make the vehicle lighter to achieve the same results.

How was the steam locomotive to meet this new challenge? The first of its past rivals had been the electric locomotive, which did not turn out to be so formidable as expected. Then came the switching Diesel-electric locomotive, very modest, with rather limited pretensions; this rival did not prove to be so important either. The latest rival, though, seemed to be serious, and the situation was met by "concentration of power."

### Concentration of Power

This was not new for the steam locomotive, especially in Europe. It was already customary in some countries of Europe to evaluate the perfection of a design of a locomotive by its "quality number." This was arbitrarily expressed by a ratio, the numerator of which was the sum of the water evaporating heating surface of the boiler and 80 per cent of the outside superheating surface, the denominator being the weight of the locomotive in working order (without tender). A more significant figure for our purpose would be the ratio of the actual power, as determined by tests, to the weight of the locomotive with half-loaded tender—this in order to make it comparable to the Diesel locomotive, which has no tender, but carries a supply of fuel and water. For weight calculation, the supply tanks of Diesel locomotives and trains are assumed to be always full. This ratio could be called "power concentration factor," or still better "specific power factor."

Table II gives comparative figures for the specific power factors of some modern steam and Diesel locomotives and trains. The figures are given in rail horse power per ton of weight. The horse power is in British units (660 foot-pounds per second); the weight is in American short tons (2,000 pounds); the weight of the tender is with half supply of water and fuel; the rail power for steam locomotives is taken from test, and when this is not available, is figured from the indicated horse power from test, multiplied by the mechanical efficiency of the engine drive, which is assumed to be 90 per cent. For Diesel-electric locomotives, for which usually the brake horse power of the oil engine is known, the rail horse power is figured on the efficiency of the whole transmission (electric, gear and axle) being 75 per cent. The same applies to power cars of Diesel-electric trains, and for the latter, if the power car has seats for passengers, an adjustment for this part of the weight is made. For trains and locomotives with mechanical transmission the efficiency is assumed to be 92 per cent. For turbine locomotives with direct drive by precision gears the mechanical efficiency is taken equal to 94 per cent; for turbine locomotives with electric transmission, to 75 per cent.

### STEAM LOCOMOTIVES

When multiplied by the ratio of the weight of the locomotive with half loaded tender to the weight of the train, the specific power figure represents the power input per ton of train weight and is a good criterion for the ability of the locomotive to accelerate the train.

Thus, as can be seen from Table II, the greatest concentration of power has been achieved, so far, by the steam locomotive, and in this respect the most remarkable results have been attained by the now famous Pacific locomotives of the Paris-Orléans-Midi Railway of France.

Since 1908 this railway has had a great number of Pacific type locomotives which first had been built as four-cylinder compound locomotives for saturated steam, and later as two-cylinder locomotives for superheated steam. Still later (1912) the railway tried four-cylinder compound locomotives with superheated steam and found them to be very efficient. These locomotives have been in exclusive use on the P.O.-Midi Railway for high-speed passenger trains for more than twenty years.

As the size and weight of locomotives, especially in Europe, were approaching their limit, the increase in power could be achieved only by increasing efficiency. Furthermore, due to conditions of economic depression, it became impossible for the French railways to buy new power. Mr. André Chapelon, mechanical engineer of the P.O.-Midi railway, decided to find out what could be done in order to increase the efficiency and the power of their Pacific locomotives. He realized first that too much wire drawing was taking place in the steam passages of the cylinders. Therefore, it was obvious to him that the passages must be enlarged. The "circulation of steam," as it is called in France, had to be improved. This necessitated changing the cylinder castings, making the steam passages wider.

The valve motion was to be changed too. Poppet valves were, in the opinion of Mr. Chapelon, a better means for steam distribution. He did not go, however, to the new rotary cam poppet valves, as this would require too many alterations in various parts of the locomotive, and furthermore, he did not wish to give up the advantages of the Walschaert gear for railroad operating conditions. He found it sufficient, retaining the Walschaert valve gear, to connect it to Dabeg (Lentz) poppet valves. He considered it important to give the valves, especially those of the exhaust, ample dimensions. They were made: for the high pressure cylinders, $7\frac{7}{8}$ inches, both for admission and exhaust, and for the low pressure cylinders, $8\frac{5}{8}$ inches for admission and $9\frac{7}{16}$ inches for exhaust. At the same time, cylinder dimensions were enlarged, increasing this volume by approximately ten per cent. Thus, the power of the locomotive was increased, in addition to the improvement in efficiency. Figures 1 and 2 show the longitudinal and cross sections of the Pacific locomotives at one stage of the transformation.[1, 2, 3]

The next modification was the adoption of the Kylala, known also as the KC, or Kylchap, smoke box arrangement. In this the exhaust is divided into four jets directed in an intermediate petticoat, from which the steam is further exhausted into an ordinary petticoat before entering the stack. Special tests made on the Paris-Orléans in 1929 proved that with the same back pressure, the vacuum in the smokebox could be almost doubled. By using the duplex arrangement, tried on some American four-cylinder Mallet locomotives—two stacks, two nozzles, two sets of petticoats, alongside one another in the longitudinal centre plane—the back pressure decreased while the vacuum increased considerably. Thus, more power could be obtained from the steam in the cylinders, increasing the evaporation and improving the combustion.

Instead of the Schmidt superheater, a new superheater known as the Houlet was adopted, which is claimed to give about 50 degrees F. more superheat due to the use of better tube proportions and more effective heat exchange. The large flues of the type "A" Schmidt superheater were retained. The principal dimensions of the firebox and boiler remained unchanged, but the firebox was rebuilt and made of steel. The pressure was raised from 230 to 288 pounds per square inch and a Nicholson syphon was intalled.

With these simple means and general refinement in the machinery, like channelling outside rods, improving counterbalancing, etc., several locomotives were first tried out. The results were surprising. The increase in power amounted to 30-40 per cent, due mainly to the improved efficiency of the locomotive. Other locomotives were rebuilt and tried out, giving similar results, not only on the P.O., but also on other roads. On some, like Nord, Est, the modifications were simply duplicated and converted locomotives bought from P.O.-Midi; on others (Etat, P.L.M.), the modifications were further developed. Thus, dozens of the old P.O. locomotives, some twenty-eight years old, but now rejuvenated by Monsieur Chapelon, are doing at present splendid work on the French roads. They are probably the most powerful, and are among the most economical in Europe. The Houlet superheaters, however, have given some trouble when the boilers were forced and the temperatures were high; some parts of the units had to be made of heat resisting steel, a practice which is now being tried by at least one more French railroad.

The steam and coal consumptions per drawbar horse power hour on the latest Chapelon locomotives are given in Table III. The curves are rather flat and when analyzed, bear witness to the remarkable achievement in the efficiency of the locomotive.

Table III
Minimum Water and Coal Consumption per D.B.H.P. hr.

| Speed m.p.h | Water, lbs. | Coal, lbs |
|---|---|---|
| 43.5 | 14.5 | 1.91 |
| 55.9 | 15.6 | 2.02 |
| 68.4 | 16.3 | 2.23 |

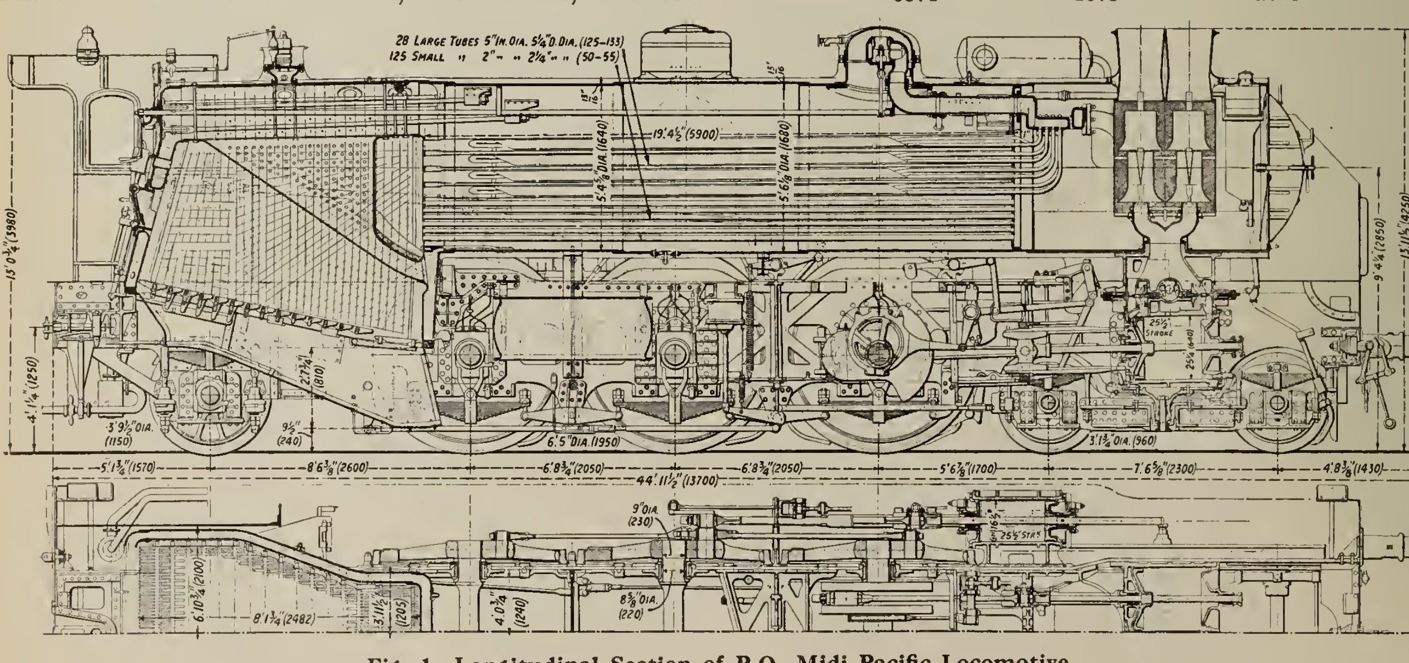


**Fig. 1—Longitudinal Section of P.O.-Midi Pacific Locomotive.**

The author was fortunate in having had the privilege of witnessing the specially made test with train No. 7 from St. Pierre des Corps to Bordeaux on October 3rd 1935, with one of the latest converted Pacific locomotives, No. 231-726 (Fig. 3). At the test, the timing of the Sud Express was followed, but the tonnage was considerably enlarged, namely, instead of a normal 235 metric tonnes, the locomotive pulled 622 tonnes (686 short tons), or a train 2.65 times as heavy. A speed fluctuating around

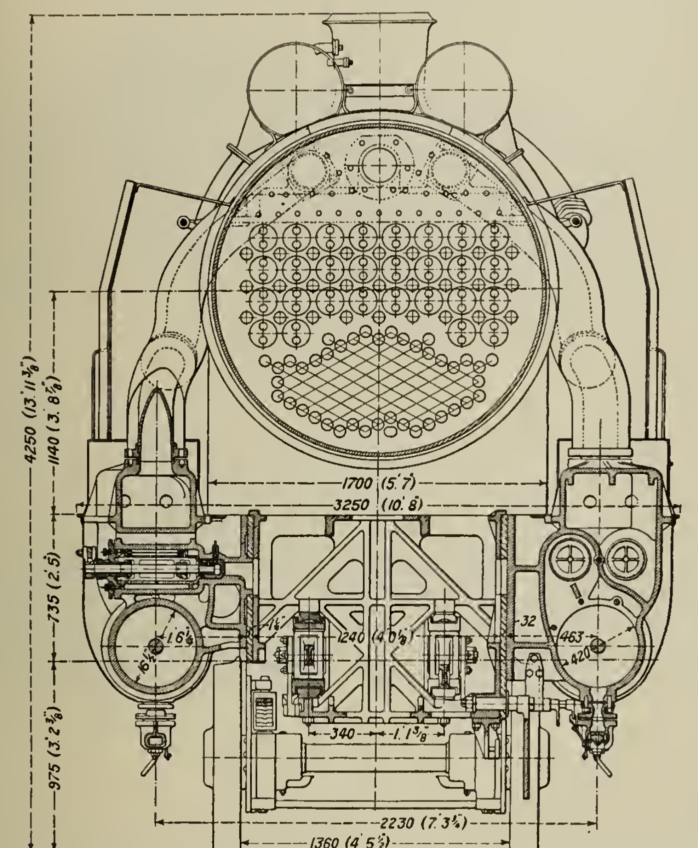


**Fig. 2—Cross Section of P.O.-Midi Rebuilt Pacific Locomotive.**

120 klm. (74.6 m.p.h.) (which is the permissible limit for steam locomotives in France with scheduled trains), was constantly maintained and average speeds of 70 m.p.h. and over were made on the trip between stops—see dynamometer chart between Angouléme and Poitiers (Fig. 4). The power chart for miles, between Angouléme and Charmant, on 0.5 per cent grade, registered 2,100-2,300 d.b.h.p. Adding the locomotive air resistance, friction, and gravity resistance to the drawbar horse power, would give about 3,500 rail horse power.

A number of 4-8-0 locomotives were likewise rebuilt from the same Pacifics. One of them is shown on Fig. 5. This locomotive developed a speed on a level of 150 klm. (93.2 miles) per hour with eight cars weighing 410 tonnes (452.6 short tons).[4, 5]

### Steam Locomotives on Other French Railways

The P.O. locomotives have proved so satisfactory that practically all railways in France adopted their ideas and even bought locomotives from the P.O.-Midi Railway wholly or partly modified in accordance with Chapelon's ideas. This was also due to the fact that French railways during the depression time were dependent upon government subsidies, and as a result, were encouraged to buy converted locomotives from the P.O.-Midi Railway, rather than new ones from builders. However, some new locomotives were also built, with changes to the P.O. recommendations. At present there is a total of 515 locomotives on French railways, converted or new, of the P.O. design. They are distributed as shown in Table IV.

Table IV
Distribution of Chapelon Locomotives on French Railways

| | P.O. | Nord | Est | Etat | A.L. (Alsace-Lorraine) | P.L.M. |
|---|---|---|---|---|---|---|
| Converted Locomotives | | | | | | |
| Type 4-6-0 | .. | .. | 90 | .. | .. | .. |
| Type 4-6-2 | 46 | 20 | 63 | 121 | 40 | 55 |
| Type 4-8-0 | 12 | .. | 40 | .. | .. | .. |
| New Locomotives | | | | | | |
| Type 4-6-2 | .. | 28 | .. | .. | .. | .. |
| Total | 58 | 48 | 193 | 121 | 40 | 55 |

The majority of these locomotives have Dabeg (Lentz) poppet valves, but some railways preferred other valves with which they had experience of their own. Among them was the Trick double ported valve of the piston type recently developed under the name of Willoteaux, with double admission and double exhaust ports. According to the Est Railway, it has given very good results. One hundred and seventy of the converted locomotives were equipped with these valves on the low pressure cylinders. The Etat and P.O. had twenty and fifteen locomotives respectively with Willoteaux valves on the high pressure cylinders. The P.L.M. acquired fifty-five locomotives with new cylinders and old piston valves, both for high and low pressure, with longer travel. The Etat applied six with Renault poppet valves among the converted locomotives.

Similar to the valves, a variety of draft arrangements was also used on the converted locomotives. The majority had either the simple or the duplex (with two stacks) Kylchap arrangements of the P.O. locomotives. However, the P.L.M. and Est Railways retained their simple exhaust nozzles with fingers, similar to the Goodfellow nozzle used in America. (See particulars below, under "Exhaust Arrangements").

### The Machinery of the French Steam Locomotives

The railroads of France, more than those of any other country, have always been in favour of multi-cylinder engines, especially of the four-cylinder compound type. For the last fifty years, since the appearance of the first four-cylinder deGlehn and du Bousquet locomotives, this type has become universal on French railways, because of the higher thermal efficiency and better balancing of the engine. For a while, after the advent of superheated steam, it was thought that superheat would make compounding superfluous and the two-cylinder superheated engine with simple expansion was thus reintroduced, only to be soon replaced by the old four-cylinder compound engine, reinforced, though, by superheat. Since then the four-cylinder compound superheated engine has been very much in vogue.[3]

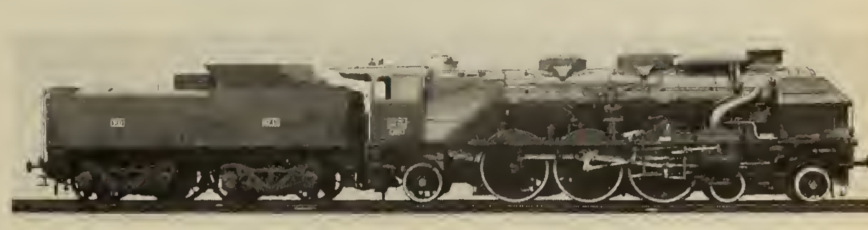

**Fig. 3—Longitudinal View of one of the latest P.O.-Midi Rebuilt Pacific Locomotives.**

However, notwithstanding the universal popularity of the four-cylinder locomotive in France, several hundred three-cylinder locomotives were built and placed in service within the last five or six years on the Est. They were tank engines of the 2-10-2 simple expansion type with superheaters, built by the Société Alsacienne des Constructions Mécaniques. Furthermore, the Northern Railway of France, where the first deGlehn locomotives made their debut about half a century ago, recently built sixty 2-8-2 locomotives of the two-cylinder superheated simple expansion type for heavy suburban traffic. They proved to be very successful. They have 25¼-inch by 27½-inch cylinders, with wide steam passages, 61-inch driving wheels, 261 pounds per square inch boiler pressure, and are able to pull, as a test on August 8th, 1932, has shown, a train of 530 short tons at a speed of slightly over 60 m.p.h. on a 0.5 per cent grade. The locomotives are equipped with cam-operated piston valves of the Cossart type, which are claimed to have very little leakage and permit cut-offs as small as 5 to 7 per cent. During the above referred to test, when the 530-ton train was pulled on a 0.5 per cent grade at 60 m.p.h., the cut-off was 10 per cent. The maximum speed of the locomotive was close to 70 m.p.h., with driving wheels only 61 inches in diameter.[6]

The same Railway (the Nord) has for its freight service 2-10-0 superheated locomotives, also with 261 pounds boiler pressure, but of the four-cylinder compound type. The high-pressure cylinders have a diameter of 19½ inches and a stroke of 26¾ inches, while the low pressure cylinders are 25½ by 27½ inches. The diameter of the driving wheels is also the same—61 inches. These, as practically all French four-cylinder locomotives, have crank axles, two of the cylinders (generally the low pressure) being the inside, and driving the first crank axle, while the outside, smaller cylinders, drive the second main axle. A very bold innovation was introduced in new 2-10-2 locomotives built by the P.L.M., in which also four cylinders, two low and two high pressure, were provided, but all four were placed outside the frame, driving the second and the fourth axles (Fig. 6). As the two rear cylinders had to be placed between the second and third driving axles, side rods could not be placed between them. However, inside side rods were employed in order to keep the outside cranks at a phase of 180 degrees for proper balancing. The inside cranks and side rods are of comparatively small size, as their main function is to keep the main cranks in proper relation and not to transfer power, which is supposed to be equally divided between the two machines. The locomotives, which have already been in service over three years, have given complete satisfaction. The front (low pressure) and the rear (high pressure) engines have Dabeg (Lentz) poppet valves.

Besides the Lentz type poppet valves of the P.O.-Midi and the P.L.M. locomotives and the Cossart cam-operated piston valves, there are one or two locomotives with Caprotti valves and gears on the Nord and several on the Alsatian (Alsace-Lorraine) Railway. A two-cylinder locomotive of the 2-10-2 type, with Caprotti valves, has just been placed in service on the latter Railway. It is the

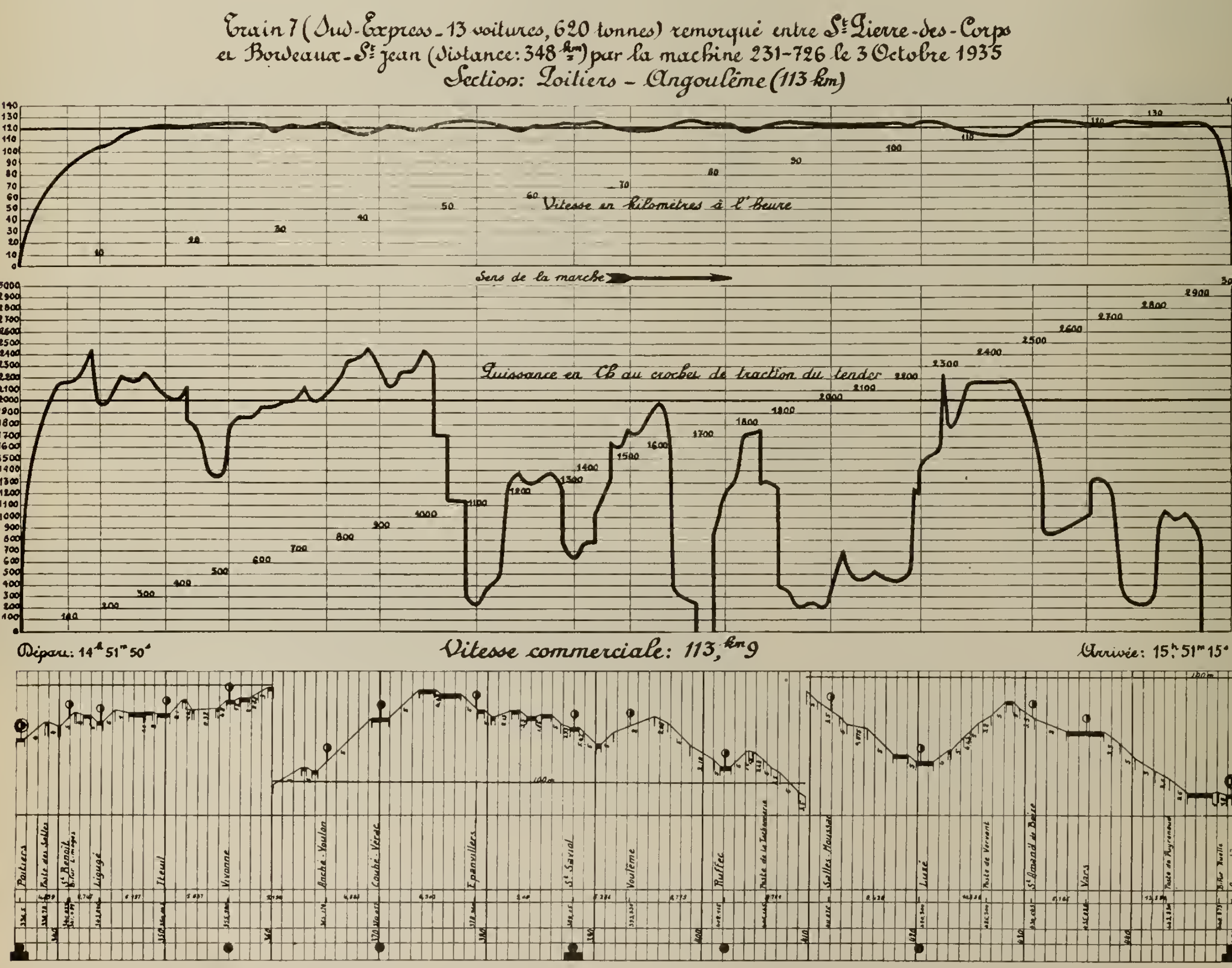


Fig. 4—Chart of Speed, Power and Profile Test with Rebuilt Pacific Locomotive on P.O.-Midi Railway.

first of two, ordered in 1935 from the Société Alsacienne des Constructions Mécaniques. It will probably soon be tested. Two other locomotives of the Pacific type, with Caprotti poppet valves, were also built by the same company and delivered to the railroad.[7]

The P.L.M. Railway, following the P.O. example, rebuilt some of their Pacifics, changing the boiler pressure from 228 to 284 pounds per square inch, increasing the cylinders and steam passages, replacing the valves by

Fig. 5—View of P.O.-Midi Converted 4-8-0 Locomotive.

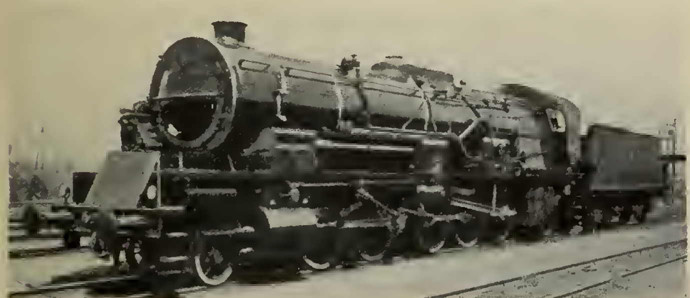

Fig. 6—View of 2-10-2 P.L.M. 4-Cylinder Compound Locomotive with Outside Cylinders.

Dabeg poppet valves, retaining, however, the Walschaert valve motion, and applying the P.L.M. double stack draft arrangement with ordinary nozzles. A regular Schmidt superheater in combination with a Dabeg feed water heater, both situated in the large flues of the superheater, were employed on one locomotive, 231-F-141.[8] It was recently tested at the stationary testing plant at Vitry and, according to information just received, has shown over 3,000 rail horse power.

Likewise, the Nord has just reconditioned a new powerful Pacific locomotive, one of the so-called "Super-Pacifics" (Fig. 7), built in 1931. The locomotive is placed in the recently inaugurated Paris-London Ferryboat train service via Dunkerque-Dover.

### Exhaust Arrangements

We have already seen that Mr. Chapelon adopted the "Kylchap" smokebox arrangement for the P.O.-Midi rejuvenated locomotives. The Nord for years had the variable exhaust with the cone which, by lifting, permitted the variation of the cross-sectional area of the jet. P.L.M. had the ordinary round nozzle with fingers, which was known under the name "trefle," meaning clover. Lately this road adopted the double nozzle arrangement, first introduced in America for some Mallet locomotives in order to separate the exhaust from the low and high pressure cylinders, the phases of which are not related. The "Kylchap" arrangement had been applied both in the single and duplex form, mainly in the latter.

All these diverse arrangements were used with a variety of petticoats and sometimes without them. Several years ago one of the engineers of the Northern Railway of Belgium, which is a subsidiary of the Nord (Northern Railway of France), by name Lemaitre, suggested a draft arrangement in which he used a central nozzle with a cone of the Nord variable exhaust, surrounded by a number of smaller nozzles (Fig. 8), into which the exhaust was directed, as well as in the central nozzle with the cone. All these jets are simultaneously admitted into a regular extension of a 19-inch stack, which, for European conditions, is fairly large.[9]

Very exhaustive tests, made by Lemaitre with a number of combinations of petticoats of different sizes, proved the advantages of reduced back pressure for a given vacuum and found the combination which best increases the output of the locomotive. On a certain test it was found on a thirty-four year old locomotive with the usual "Nord" exhaust with a varying cone, that the output of the locomotive went up, after the Lemaitre arrangement was substituted for the cone, from 1,400 h.p. at a speed of 59 m.p.h., to 1,600 h.p., or 14.3 per cent, and from 800 at a speed of 74.6 m.p.h., to 1,300 h.p., or 62.5 per cent. At this test the back pressure decreased, while the vacuum in the smokebox and the superheat correspondingly increased. Furthermore, forty locomotives equipped with the new Lemaitre arrangements have been tried out for some time past in all kinds of traffic, and the results were most satisfactory.

In view of these results, the Northern Railway of France decided to change the exhaust arrangements of seven hundred and eighty-eight locomotives of different types and classes, about one-half of the total motive power of the Railway, to the new Lemaitre type. These locomotives will include all the "Consolidation" and "Decapod" locomotives for freight, the Mikados with Cossart valves for suburban trains, referred to above, and all the "Pacific" and "Super-Pacific" type engines for the fastest expresses between Paris and Brussels, known as the "Northern Star" and "Blue Bird," and the Channel ferryboat trains between Paris and Dunkerque.

### Streamlining

It is natural that in this great activity in perfecting motive power, as displayed by the French railways within

Fig. 7—Super-Pacific Streamlined Locomotive of the Northern Railway of France.

the last few years, a certain place should have been allotted to streamlining, although it is surprising that the French engineers did it somewhat tardily. The P.O.-Midi Railway, which runs the fastest steam trains in France, until recently had no streamlined locomotives at all, and other French railways in this respect were behind railroads in other countries.

The first French railway to experiment with streamlining was the Etat, which two years ago rebuilt a twenty-seven year old 4-6-2 locomotive and placed it in passenger service. About the same time the P.L.M. streamlined a thirty year old 4-4-2 locomotive, equipping it also with a superheater and a feed water heater. They were first run in with light passenger trains up to 75 m.p.h., and then tested. This railway rendered a great service to the art, as it was the first to make tests with full-size modern equipment, while experimenters in other countries had been making tests with models only. The tests were very scientifically conducted: two locomotives, one streamlined

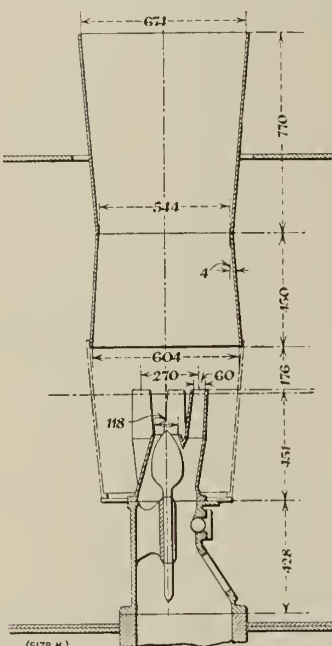


**Fig. 8—General Arrangement of Lemaitre Variable Exhaust Nozzle.**

and another not streamlined, were first tested at the testing plant of Vitry, in order to ascertain accurately the power output under certain conditions of operation (speed, throttle opening, cut-offs), and afterwards on the road with trains composed of streamlined cars and cars without streamlining, duplicating conditions of power output at Vitry. This made it possible to establish the air resistances of the locomotives and cars. It was found, for instance, that for a four-coach train a saving of 450 h.p. is obtained when locomotive and cars are completely streamlined, and only 260 h.p. are saved if locomotive alone is streamlined. Very valuable data were obtained for different conditions, and important conclusions were drawn.[10] After the completion of the tests the locomotives and train were returned to regular service.

The P.L.M. has just completed what it calls a Super-Pacific locomotive referred to above. It is fully streamlined, as can be seen from Fig. 7. The experience of the P.O. Pacific type rebuilt locomotives and of those newly built has been incorporated in the new design.

### New Developments in France

From just after the war until recently, German railways were leading in locomotive research. Turbine locomotives with condensers, high pressure steam locomotives, Diesel locomotives with different transmissions, were not only thoroughly investigated, but actually built. During the last few years, Germany having given up intentionally further construction of research units, except high-speed Diesel-electric trains and a limited number of high-speed locomotives, the French railways have been leading in this research. With the single exception of the ill-fated attempt of the P.L.M. to try the multi-pressure locomotive of the Henschel-Schmidt type, the French attacked the problem in a different way: they first started along practical lines to obtain immediate results from their existing motive power, and later they began investigating ideas disclosed in other nations' research. The P.O.-Midi conversion of old locomotives, the Kylchap and Lemaitre draft arrangements are good examples of the former, while the plans of the "Office Centrale pour les Etudes Materiel des Chemin de Fer" are pointing to the latter. The "Office Centrale" is the French central institution for motive power research, and, together with the stationary plant at Vitry for testing locomotives, became very helpful. Under the sponsorship of the "Office Centrale," which unites the research departments of all railways of the country, the following very important locomotives have been designed and their construction actually started:

1st. The Nord has ordered a 4-6-4 high pressure locomotive of the Winterthur type from the Société Alsacienne des Constructions Mécaniques, which will have a high pressure, 60 atm. (853 pounds per square inch) boiler of a special welded design. A similar boiler was tried out several years ago on a small 2-6-2 locomotive built by the Schweizerische Lokomotiv Fabrik (S.L.M.) of Winterthur, and demonstrated in France and some countries of Central Europe. Three axles of the French locomotive will be driven by three individual six-cylinder, horizontal, uniflow engines, acting on the axles through individual Buchli drives, as in electric locomotives built by the Brown-Boveri Company. The principal dimensions are given in Table V.

Table V

| | |
|---|---|
| Wheel arrangement | 4-6-4 |
| Number of cylinders | 18 |
| Diameter of cylinder, inches | 5.9 |
| Stroke of cylinders, inches | 10 |
| Boiler pressure, pounds per square inch | 853 |
| Diameter of driving wheels, inches | 61 |
| Grate area, square feet | 37.7 |
| Firebox heating surface, square feet | 312 |
| Total heating surface, square feet | 2625 |
| Superheating surface, square feet | 452.1 |
| Total weight, pounds | 253,000 |
| Weight on drivers, pounds | 145,500 |
| Gear ratio from engines to drivers | 1.975:1 |
| Drawbar horse power (at 49.7 m.p.h.) | 2400 |

This locomotive will have the Lemaitre exhaust arrangement.

2nd. A 4-6-0 P.L.M. locomotive is being rebuilt, replacing the old boiler by a new one of the Velox type. The engine remains of the four-cylinder compound type, the cylinders retaining their present dimensions—high pressure 13.4 by 26.7 inches and low pressure 21.3 by 26.7 inches. The chassis of the locomotive remains unchanged; the driving wheels will be 78.8-inch diameter. The Velox boiler is being built in Switzerland, will be placed vertically and will burn oil. This type of boiler is claimed to have an efficiency of 90 per cent and represents the application of an internal combustion turbine, driven by exhaust gases, a compressor and a boiler in which the fuel is burned in an atmosphere of compressed air. The installation will be made by the railway in its own shops.

3rd. A non-condensing turbine locomotive of the 4-6-4 type has been ordered from Schneider, at Creusot, and will probably be tried out on the P.L.M. and some other railroad. The boiler, which will be of the conventional design, will have a diameter of approximately 75 inches and a 39-inch long combustion chamber. The 59-inch driving wheels will be driven by individual turbines. It will thus differ from the turbine locomotive of the London, Midland & Scottish Railway in England by the absence of side rods. The total power of the turbines will be 2,675 metric h.p. at the turbine shafts at a speed of 87 m.p.h., corresponding to 10,000 r.p.m. of the turbine. The gear reduction of the individual drives, which will comprise gears and a flexible drive of the Buchli type, will have a ratio of 21.2: 1. The boiler will carry a pressure of 25 atm. (355.6 pounds). The grate will have an area of 52.7 square feet. The locomotive will weigh 290,000 pounds, of which 129,000 pounds will be the adhesion weight. The tractive effort for starting will be 25,500 pounds.

4th. According to rumour, another high pressure steam locomotive is also being considered now for the P.L.M. It was suggested by Bugatti and will have eight eight-cylinder

**Fig. 9—Streamlined 4-6-2 London and North Eastern Express Locomotive "Silver Link."**

**Fig. 10—Streamlined 4-6-4 German Reichsbahn Locomotive Class 05.**

engines of 250 h.p. each, directly coupled to eight axles on two trucks. Thus, there will be a total of 2,000 h.p. in 64 cylinders. The boiler will carry a pressure of 100 atm. (1,422 pounds per square inch). It is thought that the high speed express trains between Paris and the Riviera will be hauled by this locomotive at a speed of 100 klm. (62.1 miles) per hour.

### British Steam Locomotives

It has been already pointed out that Great Britain has attained a high standard in the performance of its steam locomotives. The London, Midland & Scottish and the Great Western 4-6-0 and 4-6-2 locomotives of the "King" and "Princess" class have shown excellent performance. Although they are conventional locomotives, they have been designed with great care and manufactured with many refinements. One of the L.M.S. 4-6-2 engines was built as a direct-driven 2,500 h.p. turbine non-condensing locomotive with gear transmission. The first axle, which is directly driven from the main turbine through a gear and a flexible connection, is coupled to the second and third axles by means of side rods. Sir Nigel Gresley recently stated that this locomotive has been already placed in regular service, pulling high speed L.M.S. trains.

The London & North Eastern has adhered to the conventional reciprocating steam locomotive, although several years ago it built a Pacific locomotive with 450 pounds boiler pressure. In addition to the three-cylinder 2-8-2 "Cock o' the North" and "Lord President" types, of which one locomotive was built with Dabeg poppet valves and gears, and three others with the conventional piston valves, Walschaert valve motion and Gresley gear, a new three-cylinder type of high pressure Pacifics has been developed for pulling the very high speed "Silver Jubilee" trains (Fig. 9). Three locomotives ("Silver Jubilee," "Silver Link" and "Silver Fox") have already been built and several more are contemplated. The "Silver Jubilee" trains referred to at the beginning, which are now running from London to Newcastle at an average speed of 67 m.p.h., with one stop in Darlington, will be supplemented by new trains, from London to Leeds, at an average speed of 67.5, and to Edinburgh, with an average speed of 65.5 m.p.h. The Edinburgh train will be known as the "Coronation" and will start running next spring.

In Table VI are given the principal dimensions of the "Cock o' the North" (latest edition "Lord President") and the "Silver Jubilee" (locomotive "Silver Link") types:

Table VI

| Locomotive | "Lord President" | "Silver Link" |
|---|---|---|
| Wheel arrangement | 2-8-2 | 4-6-2 |
| Number of cylinders | 3 | 3 |
| Diameter of cylinders, inches | 21 | 18½ |
| Stroke of cylinders, inches | 26 | 26 |
| Diameter of wheels, inches | 74 | 80 |
| Boiler pressure, pounds per square inches | 220 | 250 |
| Heating surface, total, square feet | 2714 | 2576.3 |
| Superheating surface, square feet | 776.5 | 749.9 |
| Grate area, square feet | 50.0 | 41.3 |
| Weight, total, pounds | 240,000 | 230,000 |
| Weight on drivers, pounds | 176,700 | 136,800 |

The boiler of the "Silver Jubilee" locomotive has a combustion chamber, probably for the first time in the history of British locomotive construction, which lengthens the firebox to 10 feet 1¾ inches. The firebox, however, is made of copper. The superheater is of the Robinson type. The locomotive and the whole train are streamlined and the finish of the inside of the train is very luxurious.

### German Steam Locomotives

Shortly after the Diesel-electric high speed, streamlined, articulated trains were inaugurated in Germany, several streamlined locomotives of the 4-6-4 type, with 2,300 mm. (90½-inch) drivers, were built, in order to compare them with Diesel-electric power. So far, locomotives of two types have been built; one comprises tank locomotives, Class 61, built by Henschel, and the others are locomotives with tenders, Class 05, built by Borsig. All have been streamlined, following tests specially made for the determination of the most advantageous shape.

**Fig. 11—View of Streamlined Double-Deck Train, Lübeck-Büchen Railway.**

The Henschel locomotives, Class 61, two of which have been built as two-cylinder simple expansion engines, are pulling light-weight trains between Berlin and Dresden at an average speed of 69.8 m.p.h. one way, and 67.6 m.p.h. on the return way on a distance of 109.3 miles. The cars have been specially built for the train, which is known as the "Henschel-Wegmann" train. The Borsig locomotives, Class 05 (Fig. 10), of which also two have been built of the three-cylinder type, are pulling regular passenger trains weighing 236 short tons between Berlin and Hamburg, on a distance of 178.1 miles, at an average speed of 74 m.p.h., slightly lower than that of the "Flying Hamburger." The third locomotive, also of the 05 Class, is now under construction. It is rumoured that it will be a pulverized coal locomotive with a combustion chamber, the first combustion chamber in Germany. It will run backwards, with the stack behind.[11] The general dimensions of these locomotives are given in Table VII:

Table VII

| Class Designation | 61 | 05 |
|---|---|---|
| Builder | Henschel | Borsig |
| Number of cylinders | 2 | 3 |
| Diameter and stroke of cylinders, inches | $18\frac{1}{8} \times 29\frac{1}{2}$ | $17\frac{11}{16} \times 26$ |
| Boiler pressure, pounds per square inch | 284 | 284 |
| Diameter of wheels, inches | $90\frac{1}{2}$ | $90\frac{1}{2}$ |
| Total evaporating heating surface, square feet | 1646.3 | 2760.6 |
| Superheating surface, square feet | 742.4 | 968.8 |
| Grate area, square feet | 29.7 | 51.7 |
| Weight in working order, total, pounds | 277,000 | 443,600 |
| Weight on drivers, pounds | 119,000 | 123,500 |

Last summer, during a visit of the British Institution of Mechanical Engineers to Germany, a train of 160 short tons, pulled by one of the two Borsig locomotives, made an average speed of 91 m.p.h. over a distance of 250 miles, and during the journey maximum speeds of more than 100 m.p.h., and once a speed of even 115 m.p.h., were reached.*

An interesting new development is the small, streamlined, high speed tank locomotive of the 2-4-2 type built by Henschel & Son in 1935 for the Lübeck-Büchen Railway, and shown (with the train) in Fig. 11. The train, built by Linke-Hoffman, of welded steel sheets, consists of two double deck cars on articulated trucks, with a seating capacity for three hundred persons. In order to provide sufficient room, the floor of the cars between the trucks is lowered and a staircase is made in the aisle to reach either of the two decks.[12] Although it may look crowded to the American eye, the seats are very comfortable and the discharge of passengers is not causing any inconvenience. One of the author's friends, who boarded the car at an intermediate station, wrote that it was amazing to see how many passengers could get into a train of this small size. He found the trip very comfortable, with little vibration, except the swaying in the seats on the second deck on curves. The average speed of the train was about 100 klm. (62.1 miles) per hour; the maximum about 75 m.p.h.

The train does not require turning, the locomotive having one control stand in the engineer's cab in front for one direction, and another stand in the cab in the rear of the second car, for the reverse direction. The control is of the remote type, operated by electro-magnetic valves from either end. When the engineer and fireman are separated, they communicate during the trip by telephone and signals. The cylinders of the tank locomotive are $15\frac{3}{4}$ by 26 inches; the wheels are 78 inches; the boiler, which is of the conventional design, carries a pressure of 227 pounds per square inch. The locomotive is streamlined.

The cars are also streamlined; they have a very agreeable inside finish in lively colours, have a separate baggage compartment, and are air-conditioned. Only second and third class, with comfortable seats, are provided. The weight of the locomotives and cars is about 306,000 pounds. The train is nicknamed "Mickey Mouse."

Two trains were in operation last summer and a third train had been ordered. Each of the first two showed an average mileage of 77,000 miles per year. Water and coal consumption per 1,000 miles were 43.6 and 38.6 per cent respectively less than for comparative passenger traffic with conventional equipment.

A Doble railcar, one of two with a Doble boiler, carrying 1,400 pounds per square inch, and a 300 h.p. engine, is operating on another branch of the same railway. The second Doble car is operating on the Kassel district of the Reichsbahn.†

Besides these locomotives, streamlined, medium power, and small light power, two large size types are going to be developed in Germany, one having a 4-8-4 wheel arrangement with 79-inch drivers for high speed heavy passenger trains, and another of the 2-10-2 type, for heavy freight trains. The type of machinery has not yet been decided. The boilers will be of the conventional design with 20 atm. (284 pounds per square inch) pressure.

### DIESEL RAILWAY EQUIPMENT

The application of Diesel engines to European railroad equipment appeared experimentally about thirty years ago on Swedish, Swiss and Saxon railcars—all with electric transmission. Diesel locomotives are comparatively a recent development, although one of the Swedish 300 h.p. Diesel-electrics was built and used as a locomotive. Shortly after the World War locomotives of greater power (up to 1,000-1,200 h.p.) were built for Russia. Operation of Diesel high-speed trains started, as an experiment, in the autumn of 1932 and regularly in May 1933, also with electric transmission.

In Germany the Diesel locomotive is mostly used in small units up to 150 h.p., sometimes as small as 20 h.p. Several hundred locomotives of this type are now employed in Middle European countries for switching work on small stations, where the work is casual and very light. All these locomotives have, as a rule, mechanical transmission with gear boxes and clutches.[13] For big work in classification yards this type is used very seldom, steam switching locomotives still prevailing.

Recently some experimental applications have been made in Germany and England with hydraulic transmission, and in England with electric transmission. The hydraulic transmission locomotives of a power up to 250-300 h.p., have either a converter for starting, with a hydraulic clutch for running (Voith type transmission), or a hydraulic clutch with a gear box (Vulcan-Sinclair, Daimler fluid flywheel with Wilson gear, etc.). A locomotive of 1,400 h.p. was built last year in Germany with a 920 h.p. M.A.N. engine, supercharged to 1,400 h.p. and Voith transmission, but nothing has been given out about the performance of the locomotive. The electric transmission

**Fig. 12—Renault 1,000 b.h.p. Diesel-Mechanical Train.**

*These speeds, as well as those recently attained on the London and North Eastern (113 m.p.h.), are comparable with the speeds reached in America, the difference, however, being that the tonnage of the American trains is from two to three times greater. The "Hiawatha" train weighs over 480 short tons.

†The German State Railways.

is not very popular in Germany and is not used, but in other European countries it is used for powers above 200-300 h.p.

In England, the London, Midland & Scottish has recently embarked on a rather extensive programme of Diesel locomotives with electric transmission. They will soon have about two dozen 0-6-0 locomotives built by the English Electric Company and Armstrong-Whitworth, of two different types as to engines, arrangement of motors and their coupling to the driving axles.[15, 16]

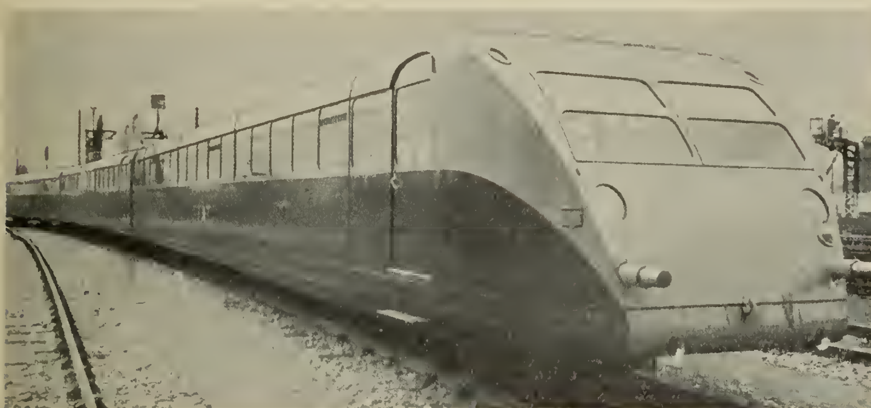

Fig. 13—800-h.p. Bugatti Train.

Ireland and Denmark have made considerable progress in the use of Diesel locomotives. The first is using Burmeister & Wain 260 h.p. Diesel engines of the new two-cycle type, and the second has, in addition to these, four-cycle engines manufactured by Frichs up to 500 h.p.

The P.L.M. and Etat in France have several experimental locomotives, the largest of which is used on the P.L.M. line in Algeria. This locomotive, which is for express trains, has an eight-cylinder M.A.N. engine of 920 h.p., is of the 4-6-4 type, and has six nose-suspended motors.[17]

There are several locomotives of 600 to 900 h.p. in Russia, both with electric and mechanical transmission, with gears and magnetic clutches, and even one or two of larger power, 1,200 to 2,400 h.p., with electric transmission. The design of the Diesel-electric locomotives is conventional and very little is known about their performance, or about the Diesel-gear locomotive which, at the time of its construction (1926), evoked much interest in this country and abroad.[18]

The European railcars, the power of which is about the same as that of the small locomotives, also have, in the majority of cases, mechanical transmission, and sometimes hydraulic transmission with gear boxes. The most interesting developments in Diesel application in recent years have been the growth of railcars in France and the high speed trains in Germany, referred to in the early part of the paper. The first has taken the form of both Diesel and gasoline cars, with mechanical transmission. About half a dozen Diesel engine manufacturers have contributed to this development. The most outstanding are the 500 and 1,000 h.p. cars of the French Etat with one or two Renault engines and mechanical transmission (Fig. 12). The latter car is operating between Paris and Havre on a schedule with 70 m.p.h. average speed. The light gasoline cars sometimes have rubber-tired wheels, due to the efforts of the well-known railcar and automobile builder, Bugatti, and of the tire manufacturer, Michelin. The latest is the new development brought about by the German "Flying Hamburger," for which the Maybach light-weight Diesel engine and the Reichsbahn should get due credit.

### Bugatti Cars

There are now in France about sixty gasoline cars built by Bugatti for the State, P.L.M., Nord and Etat Railways. They are built of two types, 400 and 800 b.h.p., and are able to haul from two to six trailers. Some of them have hydraulic transmission, but all of them have direct drives through shafts, universal joints and bevel gears. The engines are of 200 h.p. each; thus, either two or four engines are used in one car. The control is in the middle unit, in a protruding periscope-like cab, from which the visibility is very good in either direction. The top of the cab is about 13 feet above the rail. The height of the roof of the car is a few feet less. The eight-cylinder Bugatti-Royal gasoline engines develop their full power (200 h.p.) at 2,000 r.p.m., which corresponds to a speed of about 75 miles an hour, but can go up to 2,700 r.p.m., when an overload of 25 per cent is required.

The body of the car is of steel construction of sections bolted together, with rubber fillers between them. Each section is fabricated by welding. Some aluminum is also used for construction. The cars are supported by trucks, of which there are several; the 800 h.p. car consists of three units, each supported on two trucks, with eight steel-tired wheels with rubber in each, a total of 48 wheels. The body is separate from the underframe and is carried direct by the trucks with laminated springs through spherical pivots cushioned with rubber, rubber being used extensively throughout the car. The weight of an 800 h.p. car in working order varies from 40 to 80 tons, depending upon the number of seats.

The large car recently placed in service on the Etat has 152 seats and weighs 80 tons. In this case the horse power per ton of weight of the car is 10.0, including passengers and seats (not to be confused with "specific power factor," which refers to the weight of the power plant alone), but in some cases it is as high as 23 h.p. per ton, which accounts for the rapid acceleration of the cars. Figure 13 shows the latest 800 h.p. Bugatti train on the Etat.[20] The wheels are of special construction, with rubber between the steel tires and steel wheel centres for both radial and lateral cushioning.[21] A maximum speed of 87 m.p.h. is permitted for these cars in France, while 75 m.p.h. is the legal French limit for steam locomotives. Actually, the Bugatti cars reached 120 m.p.h. on several occasions.


Fig. 14—Michelin-Triple-Car Pneumatically-Tired Train.

### Michelin Cars

The French State and other railways have also Michelin cars. Hispano-Suiza, Panhard or other gasoline engines are being used in these cars, which always have mechanical transmission, sometimes through hydraulic or an electro-pneumatic epicyclic gear box (Cotal type), and steel-tired pneumatic and straight pneumatic wheels, both of special design. A 500 h.p. three-unit train built for the Etat is shown in Fig. 14. It is powered by two 250 h.p., 12-cylinder V-type Hispano-Suiza gasoline engines, has a Vulcan-Sinclair fluid fly-wheel and Cotal electro-magnetic gear transmission. The train, which is really an articulated three-unit car, is supported by two carrying and two driving trucks, the latter being in the two articulations of the middle unit. This unit is equipped with a cab, which has a periscope-like window for the driver on one side of the car. All four outside wheels of each truck have steel flanges, the inner wheels having simply pneumatic tires without any flange for guiding. The seating capacity of the three-unit train is 106, and the weight of it is 34.7 tons in working order. The maximum permissible speed of this car is also 87 m.p.h.[22,23]

LIGHT-WEIGHT TRAINS

The improvement of passenger service by placing in operation streamlined, Diesel-engined, light-weight trains was introduced in Germany shortly before the Union Pacific started a similar practice in the United States. The German train, which got the name "Flying Hamburger," began its regular operation in May 1933; before that, it was tried out experimentally for several months. Some reference to this train and its speed has already been made.

The "Flying Hamburger" consists of two articulated units with the articulation placed between the cars; in other words, the train, which weighs, in working order, but without passengers, only 85.3 short tons, is supported by three four-wheel trucks. The bodies and underframe of the cars are of high tensile steel fabricated by welding, resulting in a strong and light structure.[24]

An important feature which contributed to the lightening of the car is the engine developed in Germany by the Maybach Company in Friedrichshafen for the trans-Atlantic Zeppelins. The weight of each of the two 410 metric h.p. (405 b.h.p.) Diesel engines used for the "Flying Hamburger" is only 4,476 pounds, or 11 pounds per b.h.p. Each engine has twelve cylinders of 5⅞ inches diameter by 7⅞ inches stroke and develops its full power at 1,400 r.p.m. It permits a 5 per cent overload for one hour. Each engine with its 300 kw. generator is mounted on the corresponding front and rear power truck, while the middle, articulated, truck carries the two electric motors. The electric transmission has the Gebus differential control. Two controllers, one for each direction, are placed in each of the two end cabs, and the train travels in either direction without turning. The two ends have an identical streamlined form, which is thus a compromise in either direction. The cars have a very luxurious finish inside, carry second class accommodation for 78 to 102 passengers and, when introduced, represented an innovation which became very popular all over Europe.

During the two following years thirteen more two-unit (810 b.h.p.) and four three-unit (1,200 b.h.p.) trains were built; altogether eighteen trains should be now in operation. These trains are known as the "Flying Kölner," "Flying Frankfurter," "Flying Münchener," and so on. The three-unit trains have one hundred and thirty-nine seats and weigh 118 short tons each. They are engined by two supercharged, and thus more powerful, Maybach engines. Each V-type engine has also twelve cylinders, but the diameter was slightly increased, to 6¼ inches instead of 5⅞ inches.

Fig. 16—The Streamlined, High-Speed Train, "Flying Hamburger."

These engines, when used not supercharged on two-unit trains and railcars, retain their rating of 405 b.h.p. per engine. The engines on the three-unit trains are supercharged (on the Buchi principle) to 600 metric b.h.p. and weigh 8.2 pounds per b.h.p. Two of the four 1,200 b.h.p. trains have electric transmission and the engines are mounted with their respective generators on the two extreme trucks in the same way as on the "Flying Hamburger"; the four motors are nose-suspended on the two middle articulated trucks. The remaining two trains have the Voith hydraulic transmission with cardan universal joints and bevel gears.[25]

In addition to the regular automatic air brake and an oil pressure hand brake, used in switching, the "Flying Hamburger" as well as other German highspeed trains of this type, are equipped with electromagnetic track brakes, used only in cases of emergency. The retarding effect of these brakes is independent of the adhesive weight of the trains.

In this connection see Mr. L. K. Sillcox's unfavourable comments in his recent paper before this Institute.[26]

Other countries followed Germany in this development without great delay. France received in 1935 first two three-car, not articulated, trains (with independent trucks) and with two 405 b.h.p. Maybach engines. The average speed of the trains was not supposed to be much higher than 60 m.p.h., with a maximum of 75 miles. Orders for about ten more similar two- and three-car trains followed, both with and without articulated trucks, and the trains were placed in service on French roads. The average speeds of some of the trains are now reaching 68 m.p.h. Likewise, Belgium ordered streamlined light-weight two- and three-car trains of about the same speed, with engines of different

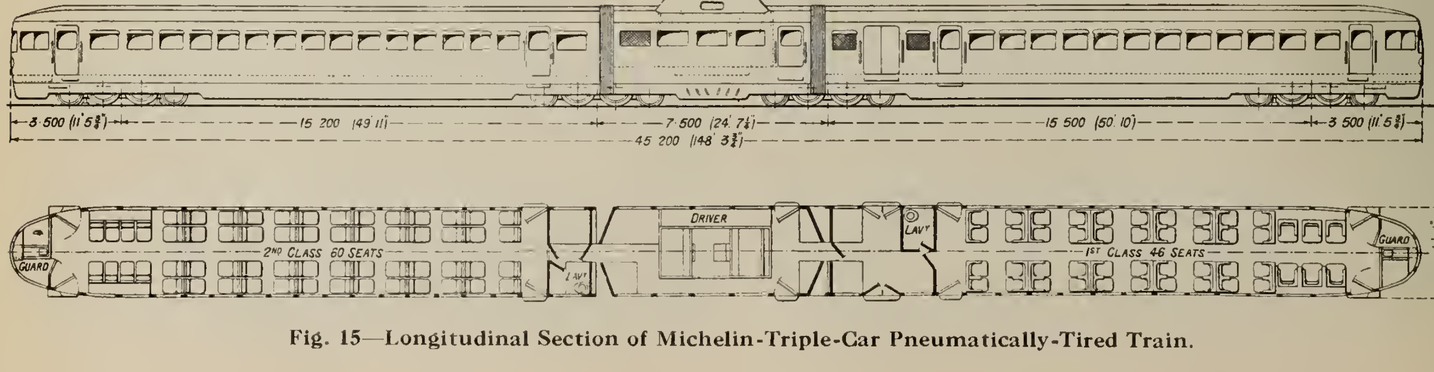


Fig. 15—Longitudinal Section of Michelin-Triple-Car Pneumatically-Tired Train.

make. The trains in Denmark, called "Lyntog," which means "Lightning," revolutionized the passenger service of that country. They have mainly Frich's engines.

The most talked of application, which received wide attention in Europe on account of the accompanying circumstances, was that made to Dutch trains. Forty trains of the three-car type were ordered almost simultaneously. Thirty-five were powered each by two Maybach engines of 405 b.h.p. of the type used on the "Flying Hamburger,"

**Fig. 17—Nord 810 b.h.p. Three-Car Train.**

while five were powered each by two 400 b.h.p. Stork-Ganz-Jendrassik engines. Shortly after the trains were placed in service, the Maybach Diesel engines on all the thirty-five trains started giving trouble, while those on the five continued their service very satisfactorily. The outcome was that the Maybach-engined trains had to be removed from service and replaced by already discarded steam power. The troubles with the Maybach engine trains were due to the unsuitable characteristics of the electric transmission, which resulted in the overloading of the Diesel engines. After some changes were made in both the engines and the transmission, the Diesel-electric trains were reinstalled.

Similar trains and railcars are now being used in Italy (the Litturinas) and Spain. The Italian trains have Fiat engines, while the Spanish have Burmeister and Wain's and Frichs'. In other European countries many light-weight, streamlined, high-speed Diesel trains and railcars are now in operation with engines of the mentioned makes. The service of these trains has proved to be very economical, with 2.7 to 4.6 pounds of fuel oil per train-mile; they are patronized extensively by the public, whose imagination was caught by the speed, comfort and novelty of the trains. They undoubtedly represent a great improvement as compared with the equipment and means of passenger transportation heretofore used on these railways,[27] but the question of ultimate economy of operation, taking into consideration their high first cost, will have to be determined later when more data are available.

This experience is in line with what we already know from the service results of the Union Pacific; Chicago, Burlington & Quincy, and other railroads which introduced light-weight, high-speed service in the United States.

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**NOTE: — For the illustrations to this paper we are indebted to the Railway Gazette, the Railway Mechanical Engineer, The Engineer, and Engineering. — Ed.**

# Report of Council for the Year 1936

The improvement in conditions noted in last year's report has fortunately continued, and has been favourably reflected in The Institute's membership roll, financial situation and branch activities. Employment has been better, particularly as regards the younger members. The Institute's revenue has exceeded the budget by a substantial amount; the increase has, however, been absorbed by unforeseen expenses including those of an additional Institute meeting and a Plenary Meeting of Council.

Throughout the year, the Council has been actively concerned with the movement for the development of co-operation between The Institute and the Provincial Professional Associations, which was discussed so fully at the Annual General Meeting in Hamilton in February 1936. It will be recalled that on that occasion the meeting adopted the 1936 report of the Committee on Consolidation "in principle as a progress report," and added representatives of the Professional Associations to the membership of that committee.

Activity in this matter has continued and has now resulted in a series of definite proposals for the amendment of The Institute By-laws, which have been prepared by the Committee on Consolidation and will be discussed at the Fifty-First Annual General Meeting to be held in Montreal on January 29th and 30th, 1937.

Throughout the committee's deliberations the Council has co-operated with the committee by affording all possible facilities for mimeographing, printing and circulating the different documents and reports, and by meeting the committee for joint discussions. The Council, in committee of the whole, has thus held two sessions jointly with the committee. At the first of these, on May 30th, possible methods of co-operation between the Council and the committee were discussed; there were submitted the preliminary conclusions of a meeting between the committee and representatives of the Professional Associations which had been held in Hamilton on February 7th, and consideration was given to the proposals from Winnipeg for a scheme of local consolidation in Manitoba.

The committee then proceeded with the drafting of its proposed revisions of the by-laws. These received preliminary consideration at a second joint session with the Council on September 18th, when suggestions for a number of changes in the draft proposals were made. The committee having considered these suggestions, finally sent its proposals to the Council on September 21st, and, as required by the By-laws, they were considered at a meeting of Council held on October 16th and 17th. At this Plenary Meeting the Council was assisted by the presence of representatives of the Dominion Council of Professional Engineers, past-presidents of The Institute, the chairman of the Committee on Consolidation, and past chairmen of the various Institute committees which have from time to time dealt with the question. The committee's proposals were discussed item by item during the sessions, which lasted some eighteen hours. With one very important exception, the Council found the proposals acceptable. The Council also suggested certain revisions and a few additional clauses, particularly a provision which would make it possible to meet the wishes of the Professional Association of Manitoba; these suggestions were later accepted by the Committee on Consolidation.

The committee's proposals are now before the membership for discussion, in a form which substantially represents the consensus of opinion of the committee and the Council. The Council desires to point out, however, that there remains the following important proposal of the committee on which there is a difference of opinion, namely, the stipulation that in future in any province whose Association has become "component," no resident who is not a corporate member of the Association can be admitted as a Member of The Institute. It is the opinion of the Council that an engineer who is not required by the law of his province to be a member of such an Association should not be subject to this prohibition.

In the Council's view, it is essential that the ballot paper which will be sent out after the Annual General Meeting shall be so drawn that the difference existing on this one point shall not prevent a clear decision by the membership on the main issue, namely whether the scheme drawn up by the Committee on Consolidation meets with their approval as a whole.

The Council desires to draw attention to the important fact, that a definite scheme for co-operation between the Associations and The Institute has now been drawn up. As in other similar cases, its provisions—a number of which are compromises between opposing views—cannot possibly fulfil the hopes of everyone. But if they are approved by The Institute as a body, they will constitute an offer to the Associations of a workable plan for joint action, which would in fact be the first step towards a unification of the engineering profession in Canada, a plan which may be modified in detail as found necessary in the light of experience gained in operation.

During the year the preparations for the celebration of the Fiftieth Anniversary of the establishment of The Institute have been actively proceeding under a Semicentennial Committee whose chairman is J. L. Busfield, M.E.I.C. The announcements and invitations which have been sent out have been warmly received, and it is anticipated that the meetings commencing on June 15th, 1937, will be largely attended, not only by Canadian engineers, but also by members and delegates from sister societies from various parts of the world.

Among the subjects of public interest which have received the attention of the Council and its committees during the year may be mentioned the Report on Tenders and Contracts for Public Works issued last year, which has given rise to appreciative comment; the work of the Committee on the Deterioration of Concrete Structures, which has now commenced under the chairmanship of R. B. Young, M.E.I.C.; and the work of the Committee on Western Water Problems, under the chairmanship of G. A. Gaherty, M.E.I.C. The Council has also been able to co-operate with the National Construction Council in connection with that body's investigations on low cost housing, and research on construction materials.

Several questions affecting the welfare of engineers as a profession have been suggested and are under consideration by Council. Among these may be mentioned the desirability of studying the supply and demand for technically trained men in Canada with a view to affording vocational guidance for young men desiring to enter the various branches of the profession. Allied with this subject is that of the status and remuneration of engineers, in connection with which it is thought that work similar to that carried out some five years ago by the Institute's Committee on Classification and Remuneration of Engineers could now be undertaken with advantage, so that up-to-date information in line with present day conditions might be available. The Council has felt, however, that other problems of importance to the Institute which are now claiming attention must be decided before it would be proper to initiate these new inquiries.

The policy of holding a number of Council meetings away from Headquarters has been followed during 1936 as far as possible. Well attended meetings of the Council were held in Toronto on May 8th and November 27th, and in Saint John on August 28th; an opportunity for the latter being provided by the Maritime Professional Meeting.

The Council received with appreciation an invitation from the American Society of Mechanical Engineers to have Institute members participate in the meeting of that Society which was held in Niagara Falls, New York, on September 17th to 19th, 1936, an invitation which was largely responded to, particularly by our Ontario members.

The Council has most willingly accepted an invitation from the American Society of Civil Engineers to participate in a joint meeting with that body to be held in Boston during the month of October 1937. Arrangements for this meeting are in the hands of a committee of which Past-President J. M. R. Fairbairn is the convenor.

The Third World Power Conference, held in Washington at the invitation of the President of the United States, from September 7th to 12th, 1936, was the occasion of a brief visit to Canada by a large number of the European and American delegates to the conference. The Institute could not participate officially in the welcome extended to the visitors by the Canadian Provincial and Federal government authorities, but it was gratifying that our branch organizations and individual members were able to take such a prominent part in the proceedings. Local committees, made up largely of Institute members, looked after many of the details of the Canadian visit in an admirable manner, and expressions of gratitude and appreciation have since been received from a number of the visitors, indicating that their experiences in Canada were of a very pleasant and informative character.

The Fiftieth Annual General Meeting convened at Headquarters on January 23rd, 1936, and was adjourned to the Royal Connaught Hotel, Hamilton on Wednesday, February 5th. The whole of that day was devoted to a discussion of the report of the Committee on Consolidation, the result being the adoption of the report, and the addition to the Committee on Consolidation of representatives of the Professional Associations.

On the morning of the following day the regular business of The Institute was transacted; this was followed by the professional sessions on Friday, February 7th, with a symposium of papers on transportation problems as the principal technical feature. Sir Edward Beatty addressed the members, ladies and guests present at the Annual Dinner of The Institute. Although the social features of the meeting were limited, in view of the death of his late Majesty King George V, the meeting was largely attended, and its success reflected credit on the executive committee and members of the Hamilton Branch, on whom so much of the preparatory and organizing work had fallen.

The second important Institute meeting of the year was organized by The Institute branches in the Maritime Provinces, and took place at Saint John on August 27th, 28th and 29th. The meeting was held in co-operation with the New Brunswick and Nova Scotia Associations of Professional Engineers. The professional sessions were characterized by a series of papers on the important road reconstruction work which is being carried out in New Brunswick and Nova Scotia; a paper on modern air conditioning; and one on the extensive reconstruction work in Saint John Harbour, which is now approaching completion, under the supervision of the Saint John Harbour Commissioners. This two million dollar project is of special interest owing to the severe tidal and weather conditions obtaining at Saint John. At the conclusion of the meeting a large number of the members and guests visited Eastport, Maine, and inspected the Passamaquoddy tidal project, a power scheme on the first portion of which substantial progress has been made. The success of these visits and of the whole meeting was the result of the activity and hospitality of the Saint John members and was aided by favourable weather conditions.

### Roll of The Institute

During the year 1936, two hundred and fifty-eight candidates were elected to various grades in The Institute. These were classified as follows:—One Honorary Member, twenty-four Members, fifty-two Associate Members, twenty-eight Juniors, one hundred and forty-six Students, and seven Affiliates. The elections during the year 1935 totalled two hundred and twenty-three.

Transfers from one grade to another were as follows:—Member to Honorary Member, one; Associate Member to Member, sixty-three; Junior to Associate Member, forty-five; Student to Junior, fifty-one; Student to Associate Member, thirty; Junior to Member, one; a total of one hundred and ninety-one.

The names of those elected or transferred are published in The Journal each month immediately following the election.

### Removals from the Roll

There have been removed from the roll during the year 1936, for non-payment of dues and by resignation, seventeen Members, sixty-nine Associate Members, twenty-six Juniors, sixty-four Students, and three Affiliates, a total of one hundred and seventy-eight.

Fifty-two reinstatements were effected, and eighteen Life Memberships were granted.

During the year 1936 twenty-one names were placed on the Non-Active List, which now numbers three hundred and seventy-six.

### Deceased Members

During the year 1936 the deaths of thirty members of The Institute have been reported as follows:—

#### Members

| | |
|---|---|
| Burpee, Moses | Marsh, Karl H. |
| Clark, Farley Granger | Ross, Alexander Bell |
| Douglas, James Atkinson | Ross, Robert Alexander |
| Faulkner, Frederick Richardson | Sykes, Samuel H. |
| Finlayson, Ernest Herbert | Thomson, Frederick |
| Freeman, Philip A. | True, Abbott |
| Hart, Henry Utler | Wallace, Joseph Harrison |
| Hyndman, Walter Eardley | Williamson, F. Stuart |
| Ketchen, William Laird | Zuercher, Max |
| MacKinnon, George Douglas | |

#### Associate Members

| | |
|---|---|
| Boyer, Aurelien | Thornton, Henry Edgar |
| Labelle, Joseph | Walshaw, John Henry |
| Murray, Robert Hutchison | Weekes, Abel Seneca |
| Reakes, George | White, Frank Clinton |

#### Junior

Larrivee, J. Albert Edouard

#### Students

| | |
|---|---|
| Lackey, Wesley James | McIntosh, Douglas Elliott |

### Total Membership

The membership of The Institute as at December 31st, 1936, totals four thousand, two hundred and thirteen. The corresponding number for the year 1935 was four thousand, one hundred and thirty-three. These figures do not include those names which are on the Non-Active List.

| 1935 | | 1936 | |
|---|---|---|---|
| Honorary Members | 7 | Honorary Members | 9 |
| Members | 976 | Members | 1,028 |
| Associate Members | 1,983 | Associate Members | 1,988 |
| Juniors | 320 | Juniors | 326 |
| Students | 810 | Students | 821 |
| Affiliates | 37 | Affiliates | 41 |
| | 4,133 | | 4,213 |

Respectfully submitted on behalf of the Council,

E. A. Cleveland, M.E.I.C., *President.*
R. J. Durley, M.E.I.C., *Secretary.*

### Treasurer's Report

During the past twelve months the course of events has fully justified the confidence expressed by the Treasurer in his report of last February, for The Institute's revenue for 1936 shows a substantial increase over that for 1935, and, what is even more gratifying, practically all items of revenue show an increase over the budgeted amounts. Thus The Institute, in the face of an unforeseen additional expenditure of some $6,000, has been able to close the year's operation with an excess of expenditure over revenue of only $1,100.

As regards the future, the Treasurer would call attention to the financial aspect of the Consolidation Committee's proposals which are now before the membership. If, as we hope, all the Professional Associations agree to co-operate with The Institute as Component Associations, it should be possible to relieve The Institute's Headquarters of some of its present office work in connection with membership records, the admission and transfer of members, and the collection of fees; a moderate reduction in Headquarters expense might then be possible. It is to be noted, however, that Headquarters would still have to look after the publications of The Institute, its professional meetings and papers, the employment service, the library and information bureau, and other service work which at present occupies the major part of the time of the Headquarters staff. But if only a minority of the Associations co-operate, Headquarters would still have to function substantially as at present.

In view of the above, it is evident that in the event of the by-law revisions passing on ballot, no really substantial reduction in The Institute's expenditure can be expected until the new organization has received general acceptance. Therefore, it should not be assumed that if the membership approves the present proposals, the counting of the ballot will be immediately followed by a considerable financial saving.

Respectfully submitted,
J. B. Challies, M.E.I.C., *Treasurer.*

### Finance Committee

The President and Council:

Your Finance Committee in submitting the auditors' report for 1936, wish to add a few supplementary figures in order to present to the membership a clear view of the financial situation as it has been developed throughout the year as well as of the significance of the statement.

After the preparation of the budget early in February at which time revenue and expenditure were estimated to

COMPARATIVE STATEMENT OF REVENUE AND EXPENDITURE FOR THE YEAR ENDING 31st DECEMBER

**Revenue**

| | 1935 | 1936 |
|---|---|---|
| Membership Fees: | | |
| Arrears | $ 3,399.50 | $ 2,350.00 |
| Current | 22,450.84 | 24,026.67 |
| Advance | 545.21 | 618.86 |
| Entrance | 1,049.00 | 816.00 |
| | $27,444.55 | $27,811.53 |
| Publications: | | |
| *Journal* subscriptions and sales | $ 6,281.67 | $ 6,681.25 |
| *Journal* advertising | 11,940.64 | 13,585.41 |
| *Catalogue* advertising | 13,596.24 | 17,567.82 |
| | $31,818.55 | $37,834.48 |
| Income from Investments | $ 477.19 | $ 476.81 |
| Refund of Expenses of Hall | 625.00 | 640.00 |
| Sundry Revenue | 155.35 | 112.59 |
| Total Revenue | $60,520.64 | $66,875.41 |
| Excess of Expenditure over Revenue for Year | ...... | $ 1,612.39 |
| Excess of Revenue over Expenditure for Year | $ 18.28 | ...... |
| | $60,502.36 | $68,487.80 |

**Expenditure**

| | 1935 | 1936 |
|---|---|---|
| Building Expenses: | | |
| Taxes—Property and water | $ 2,019.78 | $ 2,081.05 |
| Fuel | 409.60 | 411.45 |
| Insurance | 128.37 | 165.75 |
| Light | 250.12 | 262.79 |
| Caretaker's wages and service | 878.00 | 878.00 |
| Repairs and expenses | 627.14 | 526.34 |
| | $ 4,313.01 | $ 4,325.38 |
| Publications: | | |
| *Journal*—Salaries | $ 5,637.06 | $ 5,757.91 |
| Expenses | 13,209.33 | 12,338.37 |
| *Catalogue*—Salaries | 3,756.38 | 5,235.71 |
| Expenses | 9,134.94 | 12,253.40 |
| Sundry printing | 476.37 | 437.88 |
| | $32,214.08 | $36,023.27 |
| Office Expenses: | | |
| Salaries—Secretary and staff | $10,659.09 | $10,937.11 |
| Telephone, telegrams and postage | 1,426.52 | 1,516.85 |
| Office supplies and stationery | 941.09 | 1,129.22 |
| Audit fees | 250.00 | 250.00 |
| Messenger and express | 116.42 | 130.64 |
| Miscellaneous | 159.69 | 293.86 |
| | $13,552.81 | $14,257.68 |
| General Expenses: | | |
| Plenary Meeting of Council | ....... | $ 2,167.93 |
| Annual and Professional Meetings | $ 1,795.09 | 2,477.47 |
| Meetings of Council | 107.13 | 173.53 |
| Travelling—Secretary | 213.24 | 62.84 |
| Branch stationery | 181.25 | 186.13 |
| Students' Prizes | 50.61 | 77.52 |
| *E-I-C* Prizes | 288.75 | 288.75 |
| Gzowski Medal | 17.25 | 17.25 |
| Library—Salary | 519.72 | 529.10 |
| Expenses | 452.87 | 467.34 |
| Depreciation | 160.90 | ...... |
| Interest, discount and exchange | 345.63 | 292.59 |
| Examinations—Cost less amount collected | 20.00 | 73.00 |
| Committee expenses | 632.47 | 1,104.72 |
| National Construction Council | 100.00 | 100.00 |
| | $ 4,884.91 | $ 8,018.17 |
| Rebates to Branches | $ 5,537.55 | $ 5,863.30 |
| Total Expenditure | $60,502.36 | $68,487.80 |

balance at $63,700, several important questions arose which had to be studied individually by your Committee in order that the Committee might recommend to Council a policy in regard thereto.

In order of occurrence these matters were:

(*a*) The enlargement of the scope of the catalogue (April).
(*b*) The Maritime Professional Meeting (June).
(*c*) The Plenary Meeting of Council (August).
(*d*) The heavy cost of Committee work on Consolidation.

The catalogue was, after due consideration, enlarged to cover additional fields of advertising, namely those concerned with building construction and allied features. It was expected that this policy would result in an increase in the amount of advertising and the revenue therefrom, and that the increased expenditure during the first year would not be such as to destroy the chances of reaping a financial profit on the 1936 issue. These expectations were fulfilled, but the profit as finally established, was very small. However, it is confidently believed that substantial benefits from the enlargement will be realized in future years. The budgeted figures of $15,500 revenue and $14,280 expenditure during the calendar year, have in consequence been replaced by $17,567.82 revenue and $16,990.98 expenditure. It must again be pointed out that as regards the catalogue, the auditors' report exhibits the cost of, and revenue from the "issue" instead of the income and expenditure during the calendar year with which the budget deals, and due solely to the increasing cost of production the carry over from 1935 exceeds the carry forward into 1937 by $498.13 which figures are consequently added by the auditors to the actual operating deficit to produce an apparent deficit of $1,612.39.

The encouraging situation with regard to income from fees in the early part of the year permitted your Committee to agree readily with the proposal to hold a Professional Meeting in Saint John, N.B., during August, which meeting was acknowledged by all participating to be an unqualified success. The total cost to The Institute was in the neighbourhood of $600.

Similarly, at the Council Meeting held in Saint John your Committee was able to tender its advice in response to a request for information, to the effect that the cost of a Plenary Meeting could be substantially met from revenue from all indications then in their possession, so that this very important and valuable meeting was arranged for October. The cost of the Plenary Meeting of Council exceeded the earlier estimates due to the splendid attendance thereat, but your Committee feels that it correctly interprets the attitude of the membership in stating that the meeting was well worth while.

The fourth item where the actual cost during the year has been definitely in excess of the budget allowance,

## STATEMENT OF ASSETS AND LIABILITIES AS AT 31st DECEMBER, 1936

### Assets

| | | |
|---|---|---|
| **Current:** | | |
| Cash on hand and in Savings Bank | | $ 114.05 |
| Accounts receivable | $ 2,557.19 | |
| *Less:* Reserve for uncollectible accounts | 296.86 | |
| | | 2,260.33 |
| Arrears of fees—Estimated | | 2,500.00 |
| | | 4,874.38 |
| **Special Funds**—Per Statement attached: | | |
| Investments | $ 11,285.14 | |
| Cash in Savings Bank | 1,065.45 | |
| Due by Current Funds | 1,314.98 | |
| | | 13,665.57 |
| **Investments**—At cost: | | |
| $100 Dominion of Canada 4½%, 1946 | 96.50 | |
| $200 Dominion of Canada 4½%, 1958 | 180.00 | |
| $4,000 Dominion of Canada 4½%, 1959 | 4,090.71 | |
| $500 Province of Saskatchewan 5%, 1959 | 502.50 | |
| $1,000 Montreal Tramways 5%, 1941 | 950.30 | |
| $2,000 Montreal Tramways 5%, 1955 | 2,199.00 | |
| $500 Title Guarantee & Trust Corp. Certificate, past due | 500.00 | |
| 2 shares Canada Permanent Mortgage Corp | 215.00 | |
| 40 shares Montreal Light, Heat & Power Cons. N.P.V. | 324.50 | |
| | | 9,058.51 |
| Approximate market value—$10,150.00 | | |
| **Advances to Branches** | | 150.00 |
| **Deposit**—Postmaster | | 100.00 |
| **Prepaid and Deferred Charges:** | | |
| Stationery and office supplies | 861.03 | |
| Unexpired insurance | 228.25 | |
| Expenses of 1936-37 Catalogue | 2,698.23 | |
| | | 3,787.51 |
| **Gold Medal** | | 45.00 |
| **Library**—At cost less amounts written off | | 1,448.13 |
| **Furniture**—At cost less amounts written off | | 4,599.81 |
| **Land and Buildings**—At cost (Assessed Value $57,200) | | 89,041.64 |
| | | $126,770.55 |

### Liabilities

| | | |
|---|---|---|
| **Current:** | | |
| Bank Overdraft—Secured | | $ 11,354.18 |
| Accounts Payable | | 1,856.64 |
| Rebates due to Branches | | 452.75 |
| Amount due to Past Presidents' Fund | | 1,314.98 |
| | | 14,978.55 |
| **Special Funds:** | | |
| Leonard Medal | $ 657.97 | |
| Plummer Medal | 650.25 | |
| Duggan Medal | 2,456.26 | |
| Fund in aid of Members' families | 2,287.32 | |
| Past Presidents' and Prize Fund | 5,567.44 | |
| War Memorial Fund | 2,046.33 | |
| | | 13,665.57 |
| **Surplus:** | | |
| Balance as at 1st January, 1936 | 99,738.82 | |
| *Deduct:* Excess of Expenditure over Revenue for year ending 31st December, 1936 | 1,612.39 | |
| | | 98,126.43 |
| | | $126,770.55 |

### AUDIT CERTIFICATE

We have audited the books and vouchers of The Engineering Institute of Canada for the year ending 31st December, 1936. No provision has been made for depreciation of the fixed assets during the year. Subject to the foregoing, we report that the above Statement of Assets and Liabilities and attached Statement of Revenue and Expenditure are properly drawn up so as to exhibit, in our opinion, a true and correct view of The Institute's affairs as at 31st December, 1936, and the result of its operations for the year ending that date, according to the best of our information and the explanations given to us and as shown by the books.

Ritchie, Brown & Co.,
*Chartered Accountants.*

Montreal, 13th January, 1937.

is that involved in the printing, multigraphing, postage, and other expenses incurred by the headquarters office in connection with the work of the Consolidation Committee.

Summing up, it may be stated that the extra expenses above budget expectations are almost entirely confined to these four items and reach the following amounts:—

| | | |
|---|---|---|
| Plenary Council sessions | $2,167.93 | |
| Maritime Professional Meeting | 607.47 | |
| Extra Committee expenses | 771.89 | |
| Catalogue | 2,710.98 | |
| | | $6,258.27 |

This excess cost of operation has been financed to the extent of $5,144.01 from savings in other items and from revenue as follows:—

| | | | |
|---|---|---|---|
| (*a*) Revenue increases: | | | |
| Fees and subscriptions | $ 292.78 | | |
| Journal advertising | 785.41 | | |
| Catalogue | 2,067.82 | | |
| Sundry items | 29.40 | | |
| | | $3,175.41 | |
| (*b*) Savings in expenditure: | | | |
| Production of Journal | $1,803.72 | | |
| Sundry small items | 164.88 | | |
| | | 1,968.60 | |
| | | | $5,144.01 |
| So that the operating deficit for the year is actually | | | $1,114.26 |

The adjustment of the catalogue account in order to cover the "issue" instead of the calendar year, is as follows:—

| | |
|---|---|
| Deferred charge carried forward from 1935 statement | $3,196.36 |
| Deferred charge carried forward into 1937 statement | 2,698.23 |
| | 498.13 |
| Actual operating deficit for the year | 1,114.26 |
| Apparent deficit as shown in Auditors' report | $1,612.39 |

Revenue from fees unfortunately fell away after October and the indications of the monthly statements previous to that date to the effect that $700 or $800, might be looked for, over and above the budgeted estimate, finally gave way to the actual increase above mentioned of $292.78. In this connection the opinion can hardly be avoided that the imminence of a ballot of the consolidation question has given rise to some hesitancy on the part of members whose fees are still outstanding.

Your Committee has given continued and careful consideration during the year to overdue fees and has endeavoured as far as practicable to deal reasonably and even generously with all members whose situation renders it difficult for them to fulfil their obligations promptly. It is felt, however, that the time has arrived when the non-active list should be sensibly reduced from its present length in view of the undoubted improvement in the general conditions among the membership in respect to employment and remuneration.

The Committee in charge of the Semicentennial celebrations has not called upon the regular funds of The Institute for any of its expenses but has established an entirely independent fund which it is obtaining by special means and for which it will account directly to Council.

The Journal, both in respect of revenue and cost, constitutes a matter for gratification and for definite congratulation to the Headquarters staff. The income from advertising exceeded the budget by $785.41, while the cost of production was kept below the estimate to the extent of $1,803.72, a total advantage of $2,589.13.

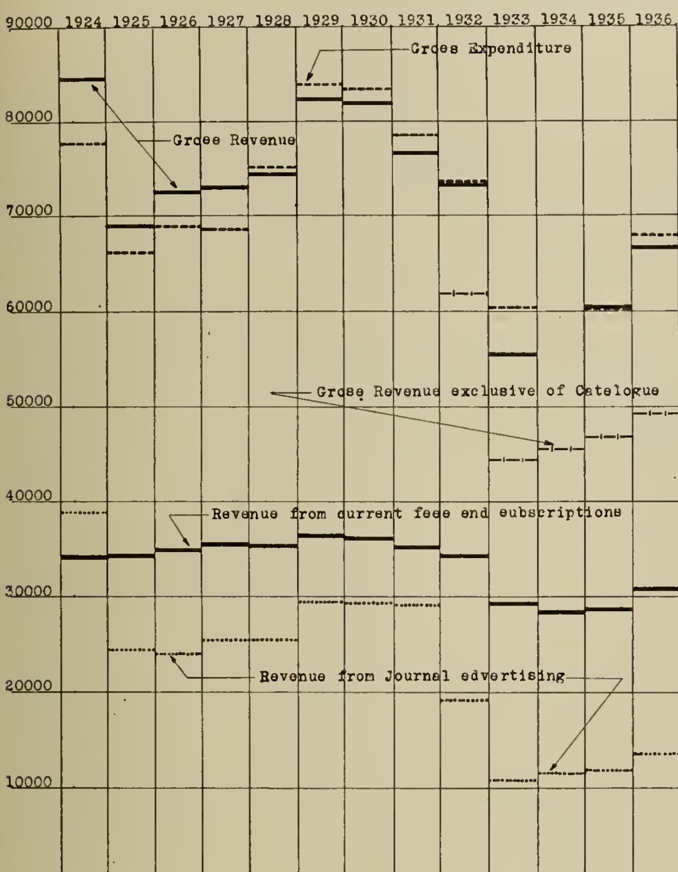
The general trend of income and expenditure can be well visualized by extending the graphs incorporated in the

## SPECIAL FUNDS AS AT 31st DECEMBER, 1936

| | | | | | |
|---|---|---|---|---|---|
| *Leonard Medal Fund:* | | | *Represented by:* | | |
| Balance as at 1st January, 1936 | $ 643.45 | | $500 Title Guarantee and Trust 6% 1933 | | |
| *Add:* Bond interest | 30.00 | | Certificate | $ 500.00 | |
| Bank interest | 1.77 | | Cash in Savings Bank | 157.97 | |
| | 675.22 | | | | |
| *Deduct:* Cost of Medals | 17.25 | | | | |
| | | $ 657.97 | | | $ 657.97 |
| *Plummer Medal Fund:* | | | | | |
| Balance as at 1st January, 1936 | 626.79 | | $500 Dominion of Canada 4½% 1959 | | |
| *Add:* Bond interest | 22.50 | | Bonds | 500.00 | |
| Bank interest | .96 | | Cash in Savings Bank | 150.25 | |
| | | 650.25 | | | 650.25 |
| *Duggan Medal Fund:* | | | | | |
| Balance as at 1st January, 1936 | 2,351.82 | | $2,300 Dominion of Canada 4½% 1959 | | |
| *Add:* Bond interest | 103.50 | | Bonds | 2,300.00 | |
| Bank interest | .94 | | Cash in Savings Bank | 156.26 | |
| | | 2,456.26 | | | 2,456.26 |
| *Fund in Aid of Members' Families:* | | | | | |
| Balance as at 1st January, 1936 | 2,189.60 | | $1,000 Province of Ontario 4½% 1964 | | |
| *Add:* Bond interest | 90.00 | | Bonds | 1,022.17 | |
| Bank interest | 2.72 | | $1,000 Dominion of Canada 4½% 1959 | | |
| Donation | 5.00 | | Bonds | 972.97 | |
| | | | Cash in Savings Bank | 292.18 | |
| | | 2,287.32 | | | 2,287.32 |
| *Past Presidents' and Prize Fund:* | | | | | |
| Balance as at 1st January, 1936 | 5,553.91 | | $3,000 Montreal Tramways 5% 1955 | | |
| *Add:* Bond interest | 240.00 | | Bonds | 2,490.00 | |
| Bank interest | 3.23 | | $1,500 Title Guarantee and Trust 6% | | |
| Interest on loan | 8.00 | | 1933 Certificate | 1,500.00 | |
| | 5,805.14 | | Cash in Savings Bank | 262.46 | |
| *Deduct:* Cost of Prizes | 237.70 | | Amount due by current funds | 1,314.98 | |
| | | 5,567.44 | | | 5,567.44 |
| *War Memorial Fund:* | | | | | |
| Balance as at 1st January, 1936 | 4,457.09 | | $2,000 Dominion of Canada 4½% 1959 | | |
| *Add:* Bond interest | 140.00 | | Bonds | 2,000.00 | |
| Bank interest | 3.49 | | Cash in Savings Bank | 46.33 | |
| Profit on sale of bonds | 157.64 | | | | |
| | 4,758.22 | | | | |
| *Deduct:* Cost of furnishing and erecting Bronze Memorial Tablet | 2,711.89 | | | | |
| | | 2,046.33 | | | 2,046.33 |
| | | $13,665.57 | | | $13,665.57 |

Committee's report for 1933, and published in The Journal of February 1934, page 77, to include the years 1934, 1935, and 1936, which is done in the accompanying diagram. It will here be seen that the gross figures for revenue and expenditure almost duplicate the 1925 situation, but that catalogue advertising replaces the diminution in returns from Journal advertising and current fees.

The investments of The Institute have not changed materially during the year. The market value of the




securities in the regular fund and the special funds has naturally advanced recently in keeping with general conditions and is probably higher at the moment than the cost value listed in the Auditors' statement of assets.

The current liabilities and the special funds have only moved within the normal limits, or as the purpose of the various funds has been fulfilled.

Your Committee again expresses its appreciation of the unstinted labour of the Headquarters staff and its recognition of the special pressure under which they have worked during the past year due to unprecedented activity in connection with the preparation of numerous circulars and reports for committee work. It is to be regretted that only in a partial way has it been possible to implement the hope expressed in your Committee's 1935 report regarding the restoration of salary cuts.

Respectfully submitted,

P. L. Pratley, M.E.I.C., *Chairman.*

## Nominating Committee—1937

*Chairman:* W. H. Munro, M.E.I.C.

| *Branch* | *Representative* |
|---|---|
| Halifax Branch | H. Fellows, A.M.E.I.C. |
| Cape Breton Branch | F. W. Gray, M.E.I.C. |
| Saint John Branch | F. P. Vaughan, M.E.I.C. |
| Moncton Branch | H. B. Titus, A.M.E.I.C. |
| Saguenay Branch | N. F. McCaghey, A.M.E.I.C. |
| Quebec Branch | L. P. Méthé, A.M.E.I.C. |
| St. Maurice Valley Branch | J. F. Wickenden, A.M.E.I.C. |
| Montreal Branch | P. E. Bourbonnais, A.M.E.I.C. |
| Ottawa Branch | C. M. Pitts, A.M.E.I.C. |
| Peterborough Branch | W. M. Cruthers, A.M.E.I.C. |
| Kingston Branch | A. Jackson, A.M.E.I.C. |
| Toronto Branch | J. J. Traill, M.E.I.C. |
| Hamilton Branch | H. B. Stuart, M.E.I.C. |
| London Branch | D. S. Scrymgeour, A.M.E.I.C. |
| Niagara Peninsula Branch | C. G. Moon, A.M.E.I.C. |
| Border Cities Branch | J. Clark Keith, A.M.E.I.C. |
| Sault Ste. Marie Branch | A. E. Pickering, M.E.I.C. |
| Lakehead Branch | H. G. O'Leary, A.M.E.I.C. |
| Winnipeg Branch | F. V. Seibert, M.E.I.C. |
| Saskatchewan Branch | A. P. Linton, M.E.I.C. |
| Lethbridge Branch | P. M. Sauder, M.E.I.C. |
| Edmonton Branch | H. R. Webb, A.M.E.I.C. |
| Calgary Branch | J. R. Wood, M.E.I.C. |
| Vancouver Branch | A. S. Gentles, M.E.I.C. |
| Victoria Branch | J. N. Anderson, A.M.E.I.C. |

## Semicentennial Committee

The President and Council:—

Your Semicentennial Committee has been continuously engaged since its appointment in February 1936 upon preparations for the suitable celebration of The Institute's fiftieth birthday.

Arrangements have been completed for the holding of a three day meeting in the Windsor Hotel, Montreal, June 15th to 17th inclusive, followed by a visit to Ottawa on Friday, June 18th. The programme at Montreal will include the presentation of greetings to The Institute by official delegates from many engineering societies, the holding of technical sessions, a reception and dance, banquet, and smoker. One day will be set aside for visits to engineering works, and other places of interest, and possibly a garden party will also be arranged. At Ottawa, there will be a luncheon, visits to the numerous places of interest in and around the Capital, and a dinner dance.

An important feature of the occasion will be the Semicentennial number of The Journal, containing eighteen papers, each dealing with fifty years of engineering development in Canada, by authors who are recognized leaders in the various spheres of activity. Furthermore, there will be an historic review of the Canadian Society of Civil Engineers, and The Engineering Institute of Canada. Interleaved between the papers there will be full page illustrations of notable engineering works in Canada.

One of the technical sessions will be devoted to papers which will be presented in person by engineers of prominence from Great Britain.

A symposium on the burning of Canadian coals will be an important feature of the programme. This symposium will include papers by ten authors covering conditions from Nova Scotia to British Columbia.

In addition there will be papers by twelve authors of particularly high standing in their respective fields dealing with electrical, civil, construction, transportation and general subjects.

We expect to be honoured by the presence of His Excellency the Governor-General at the banquet, and among other prominent visitors, we may mention Sir Alexander Gibb, President of the Institution of Civil Engineers; Mr. Johnstone Wright, Vice-President of the Institution of Electrical Engineers; Mr. H. E. Wimperis, President of the Royal Aeronautical Society; Mr. S. C. Hill, President of the American Society of Civil Engineers, and many others.

Respectfully submitted,

J. L. Busfield, M.E.I.C., *Chairman.*

### Past-Presidents' Prize Committee

The President and Council:—

Only one paper was received, entitled "The Engineer's Contribution to Transportation."

The committee having examined this paper, unanimously agreed that it was not of sufficient merit to be worthy of an award, and therefore recommend that no award be made for the Past-Presidents' Prize for the year 1935-1936.

Respectfully submitted,
C. N. Monsarrat, M.E.I.C., *Chairman.*

### Duggan Medal and Prize Committee

The President and Council:—

The committee ranks the following as the best papers eligible for the Duggan Medal and Prize for the prize year 1935-1936:—

"Modern Arc Welding" by David Boyd, A.M.E.I.C. and

"The Superstructure of the Reconstructed Second Narrows Bridge, Vancouver," by P. L. Pratley, M.E.I.C.

Some difficulty was experienced in selecting one of these two papers for first place, and the committee considers that both are excellent.

Respectfully submitted,
C. M. Goodrich, M.E.I.C., *Chairman.*

Note:—In view of this report and that of the Gzowski Medal Committee, the Council, at its meeting on January 19th, awarded the Duggan Medal and Prize to Mr. Pratley and the Gzowski Medal to Mr. Boyd.

### Gzowski Medal Committee

The President and Council:—

Your Committee, after giving due consideration to the papers submitted, recommend as follows for the 1935-1936 award of the Gzowski Medal:—

First choice:

"Modern Arc Welding" by David Boyd, A.M.E.I.C.

Second Choice:

"Design of Continuous Reinforced Concrete Arches" by E. Nenniger, A.M.E.I.C.

In making the above recommendation your committee was unanimous.

Respectfully submitted,
E. P. Copp, M.E.I.C., *Chairman.*

Note:—In view of this report and that of the Duggan Medal and Prize Committee, the Council, at its meeting on January 19th, awarded the Duggan Medal and Prize to Mr. Pratley, and the Gzowski Medal to Mr. Boyd.

### Plummer Medal Committee

The President and Council:—

The committee has selected from the chemical and metallurgical papers eligible for the award of the Plummer Medal for the year 1935-1936, the following as the most worthy:—

"The Metallurgy of Metallic Arc Welding of Mild Steel" by C. R. Whittemore, A.M.E.I.C.

Mr. Whittemore's paper was considered to be of value as descriptive of his original research work and study on the subject.

The second choice of several of the committee was Mr. D. L. Calkin's excellent paper on "The Soya Bean," and Mr. J. M. Somerville's paper on "The Manufacture of High Voltage Porcelain Insulators" received almost an equal rating.

Respectfully submitted,
A. G. Fleming, M.E.I.C., *Chairman.*

### Leonard Medal Committee

The President and Council:—

The committee, having duly studied the papers eligible for the award of the Leonard Medal for the year 1935-1936, would recommend that the award be made to

L. S. Weldon, M.C.I.M.M., for his paper entitled "Mining Methods and Practices at Lake Shore Mine."

This paper was presented at the Ottawa meeting of the Canadian Institute of Mining and Metallurgy in March 1936.

Respectfully submitted,
A. O. Dufresne, M.E.I.C., *Chairman.*

### Students' and Juniors' Prizes

The reports of the examiners appointed in the various zones to judge the papers submitted for the prizes for Students and Juniors of The Institute were submitted to Council at its meeting on January 19th, 1937, and the following awards were made:

*H. N. Ruttan Prize* (Western Provinces)—No papers received.

*John Galbraith Prize* (Province of Ontario)—To E. C. Hay, Jr.E.I.C., for his paper "Selection of Factors of Photo Electric Cells."

*Phelps Johnson Prize* (Province of Quebec, English)—To Eric G. Adams, Jr.E.I.C., for his paper "Trends in Population and Trade Affecting Transportation."

*Ernest Marceau Prize* (Province of Quebec, English)—To Louis Trudel, S.E.I.C., for his paper "Etude Comparative sur Modèles Réduits."

*Martin Murphy Prize* (Maritime Provinces)—No award.

### Papers Committee

The President and Council:—

The Papers Committee for the year 1936 was composed of the Chairmen of all the Branches. It was thought that in this way the local Branches might be induced to take some interest in the work of the Committee. The main duty of the Committee is to help the smaller branches to secure papers for presentation at their meetings. The larger branches and those situated near large centres of population have very little difficulty in filling their programmes with suitable papers, but the smaller branches in out of the way districts do have trouble.

From time to time certain of our prominent members have arranged to visit some of the smaller branches on their trips throughout the Dominion, and their action in this respect is much appreciated. If more of our members who are similarly placed would make the necessary personal sacrifice, we are sure the operation of the branches concerned would be greatly improved.

The Committee should be able to act as a clearing house for papers and addresses on all subjects. Certain industrial concerns have members on their staffs who can be secured to give papers on their respective processes or business. The same applies to governmental agencies, both Provincial and Dominion.

There are many series of motion picture films available at little or no rental, and these make an entertaining addition to any programme. Lists of these might be kept at Headquarters by the Chairman of the Committee.

The Papers Committee has not been able to do very much for the smaller branches, mainly because so few definite requests were received.

Respectfully submitted,
R. L. Dobbin, M.E.I.C., *Chairman.*

### Library and House Committee

The President and Council:—

Continuing the policy of the past few years of holding down expenses to a minimum, the outlay for maintenance and repairs has been kept approximately within the same range as last year.

It is considered that at the present time, with an acknowledged improvement in business, the services afforded through our library may properly be extended to meet the demands and purpose of the department. A review of the following will justify this view:

*Library and Information Service*

There has been a considerable increase in the use made of this service to members. Requests for information on technical subjects have been twenty-five per cent greater than in the preceding year. Seventy per cent more books have been borrowed, and nearly twice as many bibliographies on technical subjects have been prepared. The utility of the Library and Information Service to our members is greatly limited by the fact that only part time of one member of the staff can be spared for the work.

The small sum available for the purchase of books will only permit us to obtain a very small number of the standard textbooks and handbooks which appear during the year. Were it not for the review copies kindly sent in by publishers, and the kindness of our reviewers in returning these copies for the library, we should have few accessions of technical books.

| | *1935* | *1936* |
|---|---|---|
| Requests for information | 673 | 851 |
| Requests for textbooks, periodicals, etc. | 472 | 577 |
| Technical books borrowed by members | 89 | 153 |
| Bibliographies compiled for members | 21 | 40 |
| Accessions to library (largely reports, etc.) | 589 | 665 |
| Requests for photoprints | 17 | 22 |
| Total pages of photoprints furnished to members | 110 | 119 |
| Books presented for review by publishers | 27 | 32 |

*Building Repairs and Maintenance*

The expenditures on this account have been confined to those essential for meeting ordinary wear and tear on our property and its furnishings. A comparison of the costs for this year and the previous one follows:

| | *1935* | *1936* |
|---|---|---|
| Building maintenance | $520.00 | $526.34 |

In closing, your committee respectfully suggests that in view of the evidence of demand by the membership for increased service from the library, and as present prospects would appear to justify it, the facilities and service that it affords or can be readily made to do, be now extended. This can be accomplished by a moderate allowance in the budget for the purchase of books, periodicals, etc., which has been restricted for the past few years. We believe this policy would meet with general approval, and consider it to be in the interests of the membership at large.

Respectfully submitted,
E. A. Ryan, M.E.I.C., *Chairman.*

### Committee on Relations with National Societies

The President and Council:—

The outstanding feature of the year 1936 was the Third World Power Conference at Washington, held from September 7th to 12th, on the invitation of the President of the United States. It was financed by the United States Government and by the American public utilities organizations. Concurrently with the Conference, the International Commission on Large Dams held its second convention. The gathering was attended by delegates from fifty-two countries.

Canadian participation in the Conference and its activities was looked after by the Canadian National Committee, of which Dr. Charles Camsell, M.E.I.C., is chairman, and Norman Marr, M.E.I.C., Secretary. The arrangements for adequate Canadian representation involved an immense amount of work on the part of these two gentlemen and their committee. Five of the topics for discussion on the official programme of the Conference were the subjects of specially prepared papers by Canadians.

At the Conference the large British delegation took a leading part, and spoke with freedom and vigour in opposition to everything savouring of politics, remarking pointedly that "politics and power will not mix."

President Roosevelt appeared personally at one of the gatherings, and dramatically put into operation electrically from the meeting hall the great Boulder Dam power plant, assuring his nation-wide audience that other undeveloped millions of horse power would soon be made ready for the people if his administration were returned to office.

In almost all their deliberations the delegates from abroad dealt entirely with engineering problems and achievements, but there was a tendency for some of the American delegates to wax eloquent over the financial structures of operating companies.

The Canadian Committee, invited to act as joint host to the delegates from other countries during the post-convention tours which passed through Canada, took an active part in making the necessary arrangements. In the Montreal district, in the Ottawa district and in the Niagara Peninsula, important engineering developments were thrown open and inspected with appreciative interest.

The delegates participating in the tour were entertained by the Federal Government at dinner at Ottawa, the Minister of Transport presiding. They were similarly entertained in Montreal by the Electricity Commission of Quebec, and at Niagara Falls the Hydro-Electric Power Commission of Ontario acted as their hosts. The officers of the Hydro, the Shawinigan Company, the Beauharnois Company, and the Gatineau Power Company were most hospitable, and the delegates were greatly impressed with the industrial developments arising from the utilization of power on Canadian rivers.

After visiting Niagara, the visitors joined in the proceedings of the American Society of Mechanical Engineers, whose Fall Meeting, participated in by The Engineering Institute of Canada, synchronized with the dates of the World Power Conference tours. The Institute was represented at the A.S.M.E. dinner by the undersigned.

At the time of writing, Christmas Eve, a formal resolution of appreciation and gratitude has just arrived; it is signed by fifteen Norwegian delegates to the Third World Power Conference.

Respectfully submitted,
John Murphy, M.E.I.C., *Chairman.*

### Board of Examiners and Education

The President and Council:—

Your Board of Examiners and Education, having been re-appointed from the previous year, beg to report for 1936 as follows:

In accordance with request received from Council your Board prepared several examination papers, namely:

For examination held in May—

*Schedule B*

I. Elementary Physics and Mechanics.
II A. Strength and Elasticity of Materials.

*Schedule C*

II A. Civil Engineering General Paper.
II B2. Hydraulic Engineering.
III A. Electrical Engineering General Paper.

III B3. Utilization of Electric Power.
VII A. Structural Engineering General Paper.
VII B1. Structural Steel Design.

For examination held in November—
*Schedule C*
VII B2. Reinforced Concrete Design.

Your Board received five papers from five candidates for the May examination and from one candidate in November. These papers were marked and returned with reports to Council.

At the request of Council your Board made recommendations as to standing which should be allowed a particular prospective candidate without application and in another instance submitted a report on textbooks suitable for study for The Institute examinations.

The results of the examinations held during 1936 were as follows:—

| *Examined under* | *Number of Candidates* May | Nov. | *Numbers passed* May | Nov. | *Passed in all subjects Completely* |
|---|---|---|---|---|---|
| Schedule B (Junior) | | | | | |
| I Elementary Physics and Mechanics | 1 | .. | 1 | .. | 1 |
| II A Strength and Elasticity of Materials | 1 | .. | 1 | .. | |
| Schedule C (Associate Member) | | | | | |
| I A General Chemical Engineering | .. | 1 | .. | 1 | |
| I B7 Water Softening | .. | 1 | .. | 1 | |
| II A Civil Engineering General Papers | 1 | .. | .. | .. | |
| II B2 Hydraulic Engineering | 1 | .. | .. | .. | |
| III A Electrical Engineering General Paper | 1 | .. | .. | .. | 3 |
| III B3 Utilization of Electric Power | 1 | .. | .. | .. | |
| VII A Structural Engineering General Paper | 2 | .. | 2 | .. | |
| VII B1 Structural Steel Design | 1 | .. | 1 | .. | |
| VII B2 Reinforced Concrete Design | .. | 1 | .. | 1 | |

In conclusion, I wish to express my appreciation to the members of the Board for the ready way in which they have assisted in this work and to thank the secretary for his co-operation.

Respectfully submitted,
H. M. White, A.M.E.I.C., *Chairman.*

### Committee on Western Water Problems

The President and Council:—

The past season was again one of severe drought over a large part of the Western prairies, although the areas affected were not the same as in 1934. Present indications are that 1937 will be a poor crop year, as there is a deficiency of moisture in the soil over a large section of the country.

The Dominion Government has commenced a comprehensive study of soil and precipitation conditions in the area subject to drought, as also a survey of the economic conditions of the individual farmers. In this connection it is interesting to note that several years ago H. J. McLean, A.M.E.I.C., prepared a map based on the Government soil surveys, meteorological and run-off data, classifying the prairie into areas according to crop prospects over a period of years. The map is being used in studying the economic feasibility of transmission line extensions.

It is understood that in 1937-1938 there will necessarily be a substantial increase in expenditure under the Drought Rehabilitation Act, and that it is planned to hold a conference at Regina this spring, at which provincial, municipal, railway, federal and other representatives will be present to map out their programme for the summer. It is intended more particularly to aim at the reorganization of the western drought areas and to assist the farmer in the marketing of farm products and in the promotion of co-operative producing and distributing organizations.

The drought problem is primarily an agricultural one. For relief we must look to the improvement of farming methods and to the development of new types of wheat. The very lands that are subject to drought produce the highest grade of wheat. The engineer can render a service to the farmers on these lands by making them less dependent upon the wheat crop. In this connection a distinction should be made between irrigation for raising a cash crop and water supply to enable the farmer to grow enough vegetables for his own use and feed for his stock. While large scale irrigation is seldom economically feasible, the supply of water for these domestic purposes will support a much higher charge per acre foot.

In this direction, your Committee is able to report progress in the application of electric pumping. The flow of the rivers rising on the eastern slope of the Rockies is high in summer and low in winter and the summer is also the season when the load on the power systems on the Prairie is light. A power rate has been worked out passing on the benefit of this situation to the irrigation user. The Eastern Irrigation District of Alberta in collaboration with Calgary Power Company has recently completed a 10,000 g.p.m. pumping installation operating under a fourteen foot lift for irrigating an extensive tract of land above ditch level. A special type of pump has been developed for this service. While this installation appears to be highly successful, it is early yet to make a full report on the results obtained, or to forecast whether such installations will have any wide application in making the farmers less dependent on the wheat crop in that portion of the drought area having hydro-electric power service.

Respectfully submitted,
G. A. Gaherty, M.E.I.C., *Chairman.*

### Committee on Deterioration of Concrete Structures

The President and Council:—

During the past year the organization of the Committee on Deterioration of Concrete Structures has been completed, the membership of the committee being as follows:—

R. B. Young, M.E.I.C., *Chairman.*
G. P. F. Boese, A.M.E.I.C.
C. L. Cate, A.M.E.I.C.
A. G. Fleming, M.E.I.C.
O. O. Lefebvre, M.E.I.C.
C. J. Mackenzie, M.E.I.C.
J. A. McCrory, M.E.I.C.
J. H. McKinney, A.M.E.I.C.
R. M. Smith, A.M.E.I.C.
E. Viens, M.E.I.C.
C. N. Simpson.

The work of the Committee has commenced; its members are now preparing reports on different structures, which will later be assembled for study.

Respectfully submitted,
R. B. Young, M.E.I.C., *Chairman.*

### Honour Roll and War Trophies Committee

The President and Council:—

During the year the large bronze Record Tablet, containing the names of 949 members who served overseas with the Allied Forces during 1914 to 1918, has been cast and erected at a total cost of $2,711.89. It replaces the temporary record which was put up just after the War, and is believed to be accurate and complete. Adequate lighting has been provided, as well as for the smaller Memorial

Tablet, and the Record Tablet is ready for unveiling. It is hoped that arrangements may be made for this ceremony to take place during the Semicentennial in June next.

There remains an unexpended balance of $2,046.33 to the credit of the fund, and your committee would suggest that this amount might form the nucleus of a fund for a suitably named prize or scholarship.

Respectfully submitted,
A. E. Dubuc, M.E.I.C., *Chairman.*

## Employment Service Bureau

The President and Council:—

The Employment Service Bureau of The Institute is now able to report an improvement in employment conditions for the fourth consecutive year. The following figures show the placements effected during the past five years:—

| *1932* | *1933* | *1934* | *1935* | *1936* |
|---|---|---|---|---|
| 58 | 50 | 70 | 77 | 110 |

The following figures show the extent of the Bureau's work for 1936 as compared with 1935:—

| | *1936* | *1935* |
|---|---|---|
| Number of registrations during the year—members.... | 103 | 96 |
| Number of registrations during the year—non-members | 45 | 38 |
| Number of members advertising for positions......... | 77 | 86 |
| Replies received from employers..................... | 42 | 59 |
| Vacant positions registered......................... | 195 | 145 |
| Vacancies advertised in Journal..................... | 25 | 27 |
| Replies received to advertised positions............ | 66 | 124 |
| Men notified of vacancies........................... | 259 | 209 |
| Men's records forwarded to prospective employers..... | 746 | 518 |
| Placements definitely known......................... | 110 | 77 |

At the present time 225 members are registered with the Employment Service Bureau (which compares with 224 a year ago), 117 of whom have advised us that they are temporarily employed, or desire to change their present positions.

Over one thousand interviews were given in connection with employment during the past year.

As The Journal is published monthly, it has been found impossible to include many of the "Situations Vacant" advertisements, and latterly a mimeographed bulletin has been issued to those registered with the Bureau. It is proposed to continue the issuing of this bulletin each month during 1937, and if possible to increase its scope to include "Situations Wanted" advertisements, and the mailing list covering prospective employers.

Enquiries during the past few months indicate that the present demand for engineers appears mainly to be in the following general classifications:—

- Recent graduates in mechanical engineering.
- Young mechanical engineers with two or three years experience.
- Recent graduates in civil engineering.
- Sales engineers in all branches of engineering.
- Sales engineers speaking French.
- Engineers with pulp and paper mill experience in design, draughting and maintenance.

Employment conditions for engineers have so improved that within a few months it seems likely that the demand will exceed the supply in most parts of Canada; this has already happened in a number of specialized lines.

There are few totally unemployed engineers at the present time. There are, however, some who are temporarily out of work for the winter months, particularly in the Maritime and Western Provinces. There are still a considerable number of experienced construction engineers in unsatisfactory positions.

Reports from various Branches on the Unemployment Situation were received in December 1936, as follows:—

*Saint John Branch*

Although there are a few unemployed, especially among Students and Juniors, the employment situation shows considerable improvement.

*Moncton Branch*

None of the Corporate Members of the Branch are unemployed. There is one Student who is trying to find work.

*Peterborough Branch*

Employment conditions for engineers in this district are practically on a level with those of pre-depression years.

*London Branch*

To our knowledge only one engineer is unemployed at the present time.

*Lakehead Branch*

As far as is known, all engineers of the Branch have been employed for the greater part of the past year. Some of the work has been temporary but little difficulty has been had in placing engineers. Several engineers were brought in from outside districts. Remuneration has not yet reached a satisfactory level. This Branch has had only one case in which financial aid was necessary. This was the case of an aged transient engineer who was provided for until work was obtained for him in the mining area.

*Sault Ste Marie Branch*

The unemployment committee which functioned during 1935 has been discontinued, the Executive feeling that the need for this committee was over due to the betterment of business conditions in this territory.

*Victoria Branch*

There have been no calls during the year for financial assistance and the Executive has no knowledge of any members in need of such assistance. It would appear that general conditions are improved as at least three members of the Branch are known to have bettered their positions during the year.

*Vancouver Branch*

Employment conditions amongst engineers have improved greatly during 1936. Briefly, all engineers in geological, mining and metallurgical engineering are employed. There is much improvement in conditions affecting civil, mechanical and structural engineers. There is still, however, some distress amongst electrical engineers. Indications for 1937 are that all engineers will probably be employed.

*Calgary Branch*

The situation regarding the employment of engineers in this district has improved only slightly in the year 1936. This slight improvement is due to employment of engineers on government projects and to increased activity in the Turner Valley oil fields. Several engineers of this Branch, including experienced engineers as well as recent graduates, are unemployed, and the present prospects do not indicate any material betterment of this condition in the immediate future.

*Lethbridge Branch*

To date there is no unemployment amongst the members of the Lethbridge Branch, according to data from the local committee on unemployment.

*Saskatchewan Branch*

It is safe to say that virtually all engineers in Saskatchewan were gainfully employed for at least some period during 1936. Some engineers are now unemployed by reason of seasonal conditions and a very small percentage have nothing in view at all. However, we look to 1937 with the prospect of having every engineer engaged in some kind of work even though it be only temporary employment.

Respectfully submitted,
R. J. Durley, M.E.I.C., *General Secretary.*

## Committee on Consolidation

The President and Council:—

At the Annual Meeting of The Institute held in Hamilton on February 5th, 1936, the report of the Committee on Consolidation for the year 1935 was presented, discussed, and the following resolution was unanimously passed by the meeting:—

"That the Report of the Committee on Consolidation be adopted in principle as a progress report; also that the Committee on Consolidation be continued with instructions to add to their number two members of the Dominion Council of the Associations, and be empowered to add further to their number, providing such additional members be approved by Council, and that Council and the Committee shall co-operate for the speedy consummation of consolidation, co-ordination or confederation throughout the Dominion."

The report contained the following recommendations:—

(1) That in view of the general approval which has been given the broad principle of consolidation by the profession in Canada, The Engineering Institute of Canada take immediate steps to put the same into effect with those Provincial Professional Associations with whom satisfactory arrangements can be made.

(2) That The Engineering Institute agree to accept as qualification for admission to membership in The Institute the standard of membership requirement of the Provincial Professional Associations or Corporation and that when the engineers of a Province come into Consolidation, only members of the Provincial Professional Association or Corporation of such Province shall, thereafter, be accepted into membership in The Institute from that Province.

(3) That The Engineering Institute agree to accept into membership of a certain class, upon payment of a determined nominal fee, those members of the Provincial Professional Associations coming into consolidation, who are not and may not become full members of the national body.

(4) That The Engineering Institute of Canada make representation to the several Provincial Professional Associations for the acceptance of corporate membership in The Institute as qualification for admission to the Professional Association when permissible under the law of the province. This to apply only to those who are corporate members of The Institute at the time of consolidation with such Provincial Professional Association.

(5) That The Engineering Institute apply the principle of Provincial Divisions and that the same shall include the present branches of The Institute and the membership of the Provincial Professional Associations on a system of organization and administration to be determined by a properly representative committee of the Associations and The Institute.

(6) In the event of consolidation being effected as between The Institute and any Provincial Professional Association, The Institute agree to the establishment of a properly constituted authority in such province for the collection and distribution of membership fees within the province and to the national body, in accordance with a mutually approved contract.

(7) That The Institute agree to act as the national body in the event of consolidation being consummated with any or all of the Provincial Professional Associations.

(8) That The Institute undertake to constitute the members of The Institute within any province into a Provincial Division of The Institute in that province should the Provincial Professional Association not be prepared to proceed to consolidation at this time.

(9) That The Institute continue the present Committee on Consolidation with the commission to represent The Institute in discussions with the Provincial Professional Associations and for the purpose of achieving consolidation on the general basis above outlined.

The Committee regrets that it has not been possible to submit to Council for action at this Annual Meeting, certain specific recommendations involving basic changes in the By-laws of The Institute as outlined in paragraph No. 2 of the above recommendations, which would materially facilitate the early consummation of consolidation.

---

Since the Annual Meeting of February 5th, 1936, the Committee has held nine regular meetings, one Joint Conference with the Dominion Council and other representatives of the Provincial Professional Associations and Corporation, two joint meetings with the Council of The Institute, and was represented at the Seventh Plenary Meeting of Council held in Montreal on October 16th and 17th, to consider the Committee's proposals for revisions to the By-laws of The Institute designed to effect closer co-operation between The Institute and the various Professional Associations and Corporation.

At a meeting of the Committee held on February 6th, and with the subsequent approval of the Council, Dr. F. A. Gaby was added to the membership of the Committee.

At a meeting of the Dominion Council and other representatives of the Professional Associations and Corporation, held in Hamilton on February 6th, 1936, Mr. C. C. Kirby of Saint John, N.B., and Mr. Archie B. Crealock of Toronto, President and Vice-President respectively of the Dominion Council of Professional Engineers, were appointed as its representatives on the Committee on Consolidation, and the Committee assumed a national significance.

On Friday, February 7th, an informal conference was held of the Dominion Council, the representatives of the Provincial Professional Associations, and the representatives of The Engineering Institute.

Those present at this meeting were:—

Members of the Dominion Council of Professional Engineers:—

| | |
|---|---|
| C. C. Kirby, (President). | Saint John, N.B. |
| Archie B. Crealock, (Vice-President). | Toronto, Ont. |
| Colonel F. H. G. Letson, | Vancouver, B.C. |
| P. M. Sauder, | Lethbridge, Alta. |
| D. A. R. McCannel, | Regina, Sask. |
| Professor F. R. Faulkner, | Halifax, N.S. |

Other Representatives of the Provincial Professional Associations:—

| | |
|---|---|
| E. A. Wheatley, | Vancouver, B.C. |
| T. C. Main, | Winnipeg, Man. |
| J. M. H. Cimon, | Quebec, P.Q. |
| A. B. Normandin, | Quebec, P.Q. |
| G. Stead, | Saint John, N.B. |

Members of the Committee on Consolidation, representing The Engineering Institute of Canada:—

Dr. O. O. Lefebvre,
J. B. Challies,
Dr. F. A. Gaby,
Professor R. E. Jamieson,
Gordon McL. Pitts
(Chairman).

This was a most momentous day in the history of the engineering profession in Canada, as it provided the long-sought opportunity for a round table discussion of the many details and varying points of view involved in the uniting of the engineering organizations of the Dominion into one coherent, expressive, national body. Those present appreciated the significance of the occasion and the deliberations and discussions were carried on in the spirit of the fullest co-operation and compromise.

Mr. C. C. Kirby acted as Chairman of the meeting and Mr. E. A. Wheatley as Secretary. The conference lasted throughout the day and the results of its discussions are represented in the following Memorandum.

*Memorandum of Informal Conference*

Between Representatives of the Provincial Professional Associations in Canada and of The Engineering Institute, prepared for the purpose of discussion only and without prejudice to the action by any member present at this meeting, held at Hamilton, February 7th, 1936.

We record with satisfaction and appreciation the opportunity afforded in Hamilton, this day for the first time for accredited representatives of all Provincial Professional Associations in Canada (The Associations' Dominion Council) and also The Engineering Institute (The Committee on Consolidation), to confer for the common good of the engineering profession.

We feel the opportunity thus afforded to be of such great moment to the engineering profession in Canada that it must be taken full advantage of. Therefore, we desire to place on record the following preliminary conclusions as a basis for definite progress.

1. General principles only should now be asserted. Constitutional details and precise methods of procedure to accomplish the general principles could be left in abeyance for the time being.

2. The Provincial Professional Associations must continue to function in their present capacities and for the purpose set out in their respective acts, and the E.I.C. should continue to function.

3. There should be a national engineering body for Canada, comprising within its membership all the qualified engineers of Canada.

4. The Engineering Institute of Canada can be the basis for such a national engineering body, and it is desirable that it should be.

5. To accomplish the purpose set out herein, we suggest for the consideration of the Provincial Professional Associations and of The Engineering Institute the following specific recommendations:—

(*a*) That The Engineering Institute agree to consolidate its two classes of corporate membership into one class.

(*b*) That The Engineering Institute agree to admit to corporate membership only those applicants who are members of a Provincial Professional Association.

(*c*) That The Engineering Institute agree to grant a special non-voting membership, without payment of either entrance fee or annual dues and without right to hold office, to those members of the Provincial Professional Associations who may not for the time being desire to apply for corporate membership in The Engineering Institute.

(*d*) That The Engineering Institute agree to enlarge its Council to permit each Provincial Professional Association to be represented directly by an accredited representative.

(*e*) That the Provincial Professional Associations continue their Dominion Council until such time as the purposes of the negotiations connoted by this memorandum are accomplished.

(*f*) That the Provincial Professional Associations con sider an acceptable plan by which the non-voting members referred to in paragraph "*c*" shall be encouraged to become corporate members of the national body.

In conclusion, it is the opinion of all assembled that the Provincial Professional Associations should encourage all their members to become corporate members of The Engineering Institute to the end that as soon as practicable there will be a real and a complete common membership as between the Provincial Professional Associations and the national engineering body.

---

At its meeting of March 21st, the Committee considered the recommendations of the Joint Conference, item by item, and it was unanimously agreed that they should form the basis for further progress in the development of a plan for closer co-operation mutually acceptable to the whole profession. It was further agreed that the plan should be drafted in a manner generally acceptable to the Associations, and should provide the opportunity for each Provincial Association and Corporation to avail itself of the advantages of the co-operation afforded thereby at such time as the Association might decide. It was not considered an essential principle of the plan to require that all the Associations come in simultaneously.

On April 18th, Mr. C. C. Kirby, President of the Dominion Council, met the Chairman of the Committee on Consolidation in an informal conference to study certain tentative revisions to the By-laws of The Institute prepared by Mr. Kirby in accordance with the principles approved by the Annual Meeting, the Memorandum of the Joint Conference, and the general discussions of the Committee. Mr. Kirby's proposals were circulated to the Corresponding Members of the Committee and of Council.

At its meeting of May 30th, the Committee again discussed and approved the Memorandum of the Joint Conference at Hamilton. It also considered the resolution of the Joint Consolidation Committee of the Province of Manitoba of April 29th, 1936, urging immediate action by The Institute to permit Consolidation to go into effect in that province at an early date. The Committee expressed its sympathy with this desire for early Consolidation within the Province, coupled with the hope that the engineers of Manitoba would co-operate with the Committee to the extent of delaying action until such time as the proposed revisions to the By-laws had been approved and forwarded to them.

The Committee also considered representations from British Columbia regarding simplified forms of admission to The Institute, and the tentative revisions to the By-laws as prepared by Mr. Kirby were reviewed. It further recommended to Council that the Committee be authorized to contact various engineering organizations in Ontario relative to the organization of the profession in that Province and the definition of the aims of the Committee.

Immediately following this meeting the Committee met in a Joint Meeting with the Council of The Institute, at which the "Memorandum" of the Joint Conference in Hamilton was considered item by item and duly recommended for approval by Council with the addition of the phrase, "who shall be a corporate member of The Institute," to Section 5 (*d*) of the "Memorandum." The Joint Meeting also discussed the resolution of the Manitoba Joint Consolidation Committee, and Mr. Kirby's suggested revisions to the By-laws. At a subsequent meeting of the Council the "Memorandum," as revised by the Joint Meeting, was approved.

At its meetings of July 21st, August 4th, August 21st and 22nd, the Committee gave detailed study to proposals for the revision of the By-laws of The Institute and it was decided to request a joint meeting with the Council to consider these on September 18th. This joint meeting discussed the proposals section by section and made many constructive suggestions to the Committee regarding some of the more important clauses. It was decided that a Plenary

Meeting of the Council should be held on October 16th and 17th.

On September 19th the Committee again reviewed the By-laws and the suggestions of the Joint Meeting relative thereto, and arrangements were made for the presentation of the proposals to the Council over the signatures of twenty or more members of The Institute in accordance with the provisions of the present By-laws.

The Chairman, by special invitation, represented the Committee at the Seventh Plenary Meeting of the Council, at which the By-laws were again carefully reviewed and certain modifications and additions were suggested. The results of the Plenary Meeting were reviewed by the Committee at its meeting of November 14th, and subject to minor modifications suggested by the legal adviser, all the suggestions of the Council were accepted and incorporated by the Committee into its By-law proposals with the one exception that Sub-Section 7 (*b*), which appeared in the Committee's proposals as:—

> "No person residing in any province in which there is a Component Association shall be admitted as a Member of The Engineering Institute of Canada unless he be a corporate member of such Association."

Council recommended this Sub-Section should be revised to read:—

> "No person residing in any province in which there is a Component Association, *who is required by law to be a member of that Component Association*, shall be admitted as a Member of The Engineering Institute of Canada unless he be a corporate member of such Component Association."

The Committee very carefully considered the amendment of this Section proposed by the Council, having in mind the views expressed by certain of the Associations with reference to this clause and its direct effect on the possibilities of achieving closer co-operation with the Associations, and finally came to the conclusion that it had no alternative but to adhere to the Section as originally drafted by the Committee.

In arriving at this decision, the Committee has taken the following into consideration:—

(1) Paragraph 7 of the Report of the "Committee on Relations of The Institute with the various Provincial Associations," which was accepted at the Annual Meeting of The Institute of February 12th, 1930, with one member dissenting. (See page 3, Report of the Committee on Consolidation of January 1936.)

> "That steps be taken to secure the necessary amendments to the By-laws so that membership or registration in a Professional Association be one of the requirements for admission to Corporate Membership in The Engineering Institute of Canada for all applicants residing in a province where an Engineering Professions Act is in effect."

(2) The overwhelming majority of the profession which gave an affirmative answer to question No. 2 of the Questionnaire of the Committee on Consolidation issued in June, 1935.

> "In your opinion, should the corporate membership of the Provincial Professional Associations and of the National organization be identical?"

The replies to Question No. 2 were:—

Yes, 3,868 (91.6 per cent); No, 353 (8.4 per cent).

(3) Section 2 of the Report of the Committee on Consolidation to the Annual Meeting of February 5th, 1936, which was unanimously "adopted in principle as a progress report" by that meeting.

> "That The Engineering Institute agree to accept as qualification for admission to membership in The Institute the standard of membership requirement of the Provincial Professional Associations or Corporations and that when the Engineers of a Province come into Consolidation, only members of the Provincial Professional Association or Corporation of such Province shall, thereafter, be accepted into membership in The Institute from that Province."

(4) Paragraph 5 (*b*) of the Memorandum drawn at the Joint Conference of members of the Dominion Council, representatives of Provincial Professional Associations, and the members of the Committee on Consolidation as representing The Institute, in Hamilton, on February 7th (see page 303 of The Journal for June 1936), which Memorandum was subsequently approved by the Committee on Consolidation, the joint meeting of Council and the Committee of May 30th, and further approved by Council at its meeting of June 12th, 1936. (See Journal, August 1936, page 385.)

> "5 (*b*) That The Engineering Institute agree to admit to corporate membership only those applicants who are members of a Provincial Professional Association."

(5) The Resolution of the Annual Meeting of the Corporation of Professional Engineers of the Province of Quebec, held on March 27th, 1936. (See page 13, Report of Committee on Consolidation, January 1936.) The above Resolution was further confirmed at the Annual Meeting of the Corporation in 1936.

> "That The Engineering Institute of Canada should, after the date of such change, admit no person to corporate membership who is not at the time of application a member of his own local provincial body."

(6) In addition, this By-law and the policy it embraces, has been approved by many Branches of The Institute, Joint Committees on Consolidation and Professional Associations.

Sub-Section 7 (*b*) as proposed by the Committee on Consolidation in no way affects the standing of any of the present members of The Institute and, in view of the fact that it represents a principle of co-operation which has been accepted by The Institute and recognized by the Provincial Professional Associations over a period of years, it is felt that a complete reversal of policy by The Institute at this time may be prejudicial to its efforts for closer co-operation with these Associations.

The phrase, "who is required by law to be a member of that Component Association," as proposed by the Council, is not legally practical, as it provides no authority within the profession to determine the legal qualification of the candidate and in many cases this might require an expensive court action.

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The revisions of the By-laws of The Institute as proposed by the Committee on Consolidation were officially issued to the membership in accordance with the provisions of By-law No. 75 on pages 550 to 553 of The Journal for December 1936, and a copy thereof is attached as an Appendix "A" to this report.

In connection with the present proposals for the revisions to the By-laws of The Institute, our legal adviser and the Committee on Consolidation recommended to the Council of The Institute that the occasion for such revision should be made the opportunity for re-arranging and re-numbering the By-laws of The Institute in a proper sequence that they may be presented in logical order and easily accessible form for the use of the members. The proposed sequence of re-numbering is attached to this report as an

Appendix "B" and the Committee has been advised that the Council has decided that the re-numbering and re-arrangement of the By-laws should not take place until after the ballot.

At its meeting of November 14th, and with the assistance of our legal adviser, the Committee prepared and approved a proposed form of Agreement between a Component Association and The Institute. Copy of this Agreement appears as an Appendix "C" to this report.

At this meeting the Committee also prepared and approved a proposed Form "C," being the form of Application for Admission to The Institute by a member of a Professional Association. This form appears as an Appendix "D" to this report.

At this meeting the Committee also considered the form of the ballot by which the proposed revisions to the By-laws should be presented to the membership for ratification, and it was generally agreed that Council should be requested to consult with the Committee on this matter and that the ballot should if possible take the general form as appearing as an Appendix "E" to this report.

---

The proposals of the Committee may be briefly summarized as follows:—

The status of an engineer who is registered as entitled to practise by any one of the Associations, is acknowledged by The Institute as sufficient evidence of eligibility to become a member of The Institute, with merely the formality of a signed application to complete the admission, provided proper credentials are submitted. No entrance fee will be required of such an applicant.

The Associations are to signify their willingness to co-operate with The Institute by entering into individual agreements with The Institute in accordance with the terms of these By-laws to carry out their several parts of the undertaking. The Associations so agreeing shall be styled "Component Associations" for purposes of reference.

An Association may become a Component Association by registering at one time its total corporate membership as Members of The Institute and the payment of a per capita fee to be determined by the Council.

Again, an Association may become a Component Association by entering into an agreement with The Institute to that effect with the provision that Membership in The Institute will remain optional on the part of each member of an Association. Those who do not wish to join The Institute will be styled "Associates" of The Institute for purposes of reference and can, if they wish, participate in Institute Branch meetings and receive The Journal of The Institute at the same rate as other members.

The detail work of furthering co-operation between the various Provincial Associations on inter-provincial matters and of endeavouring to obtain more uniformity in their Provincial requirements, will be delegated to a Standing Committee of The Institute to be known as "The Committee on Association Affairs." This Committee shall report to the Council and to their respective Associations.

Component Associations may appoint or elect one member each, who is a member of The Institute, to the Council of The Institute, who may act as ordinary Councillors on the affairs of The Institute and who shall constitute the "Standing Committee on Association Affairs."

In order that this "Committee on Association Affairs" shall have the opportunity to do effective work by meeting together, provision is made that such a meeting shall be held annually with expenses of the members paid by The Institute. The Institute to be recompensed for this expense by a payment or grant from each Association on the basis of fifty cents per capita for each of its members entitled to practise.

The Council of The Institute may arrange with a Component Association for the collection of fees of joint members. A Component Association paying a per capita fee will collect these fees and forward the same to The Institute in accordance with the provisions of their Agreement.

The present grade of "Associate Member" of The Institute will be abolished and all such present members shall be styled "Members." The fees for the new grade of "Members" shall be reduced two dollars a year from the fees of the present grade of "Member."

"Engineers in training" and "Pupils" of any of the Associations may be admitted to classifications of "Juniors" or "Students" of The Institute with similar nominal formality to that for corporate members.

The Institute will confine itself for future members in a province where there is a "Component Association" to members of such Association.

In considering the revisions to the By-laws proposed by the Committee, the attention of the membership is drawn to the following:—

The proposals are so designed that the present status, function, operation and administration of The Institute undergo no fundamental change in the event of none, one or all of the Professional Associations taking advantage of the co-operation for which these proposals make provision.

The proposals make possible a very material reduction in the fees of those engineers who are members of both a Professional Association and the National body.

The fees of Members are reduced.

Present Associate Members are raised to the grade of "Member" without having to pay a transfer fee ($10.00), without the complications of application, recommendation and acceptance, and without having to pay the present fee for the grade of "member." All this more than compensates the present "Associate Member" for the small additional annual fee (one dollar) he will pay as a "Member."

The financial position of The Institute is not jeopardized by these proposals. On the other hand possibilities are provided for increased revenue through greatly increased membership. Economies in administration should also be possible.

The qualifications for admission to membership are more clearly defined and the procedure for admission has been greatly simplified.

The gap between the legal and technical functions within the profession has been effectively bridged and provision is made for the elimination of those divergences in ideal and action which impede the progress and development of the profession and are bound to spring up and develop through a multiplicity of unrelated engineering organizations.

The principle of united action for the common good of the profession, individually and collectively, can now be effectively applied.

Since its inception the Committee has maintained its policy of keeping the general membership informed as to its progress through periodic reports in The Journal of The Institute. These reports have also been made available to all members of Provincial Professional Associations and the Corporation who are not at the present time members of The Institute. It is hoped that this effort toward publicity on the part of the Committee has achieved the desired result and that all members of the profession have taken the opportunity of making themselves familiar with the many aspects of this problem as it developed.

---

In conclusion, your Committee on Consolidation recommends:—

(1) That the Council of The Institute and the Committee on Consolidation being in agreement on all the proposed revisions to the By-laws of The Institute as appearing in Appendix "A" of this report, with the exception of Sub-Section 7 (*b*), these revisions be accepted by the Annual Meeting and be sent forward to ballot by the general membership without further amendment.

(2) That in view of the attitude of the majority of the Professional Associations on Sub-Section 7 (*b*) and in the interests of achieving Consolidation, every effort be made to accept the Committee's proposal on this Sub-Section without modification or amendment for submission by ballot to the general membership.

(3) That the Annual Meeting approve the form of the "Memorandum of Agreement" between The Institute and a Component Association, as submitted in Appendix "C" of this report, subject to such modification within the terms of the By-laws as may be agreeable to the Council of The Institute and the Associations and Corporation.

(4) That the Annual Meeting approve Form "C" as proposed by the Committee in Appendix "D" of this report, being the form of Application for Admission to The Institute by a member of a Provincial Professional Association or Corporation.

(5) That the ballot on the By-law proposals be drawn in the general form as appearing in Appendix "E" of this report and that the Committee on Consolidation be authorized to take part in the drafting of the form of the ballot.

(6) That subject and subsequent to the approval of the By-law proposals by a ballot of the membership, the By-laws be re-arranged and re-numbered before being printed and issued to the membership in accordance with the Index appearing as Appendix "B" of this report.

(7) That the Committee on Consolidation be continued as presently constituted to function in connection with the preparation of the ballot, and otherwise for the purposes of Consolidation, until after the results of the ballot have been announced, and that thereafter a special committee be appointed by Council to actively promote Consolidation.

Respectfully submitted.

GORDON McL. PITTS, A.M.E.I.C., *Chairman.*

For Appendix "A" see The Engineering Journal, December, 1936, pages 550-553.

## APPENDIX "B"

### INDEX

| Title | Proposed Section No. | Present* Section No. |
|---|---|---|
| Objects | 1 | 1 |
| Associations | 2 | .. |
| *Membership.* | | |
| General Qualifications for Membership | .. | 2 |
| Classes of Members | 3 | 3 |
| Title | 4 | 4 |
| Resident and Non-Resident Members | 5 | 5 |
| Honorary Members | 6 | 6 |
| Members | 7 | 7 |
| Associates | 8 | 8 |
| Juniors | 9 | 9 |
| Students | 10 | 10 |
| Affiliates | 11 | 11 |
| *Admission and Transfer of Members.* | | |
| Honorary Members | 12 | 25 |
| Applications for Admission or for Transfer | 13 | 26 |
| Consideration of Application for Admission or for Transfer | 14 | 27 |
| Election and Transfer | 15 | 28 |
| Notification of Election | 16 | 29 |
| Certificate of Membership | 17 | 30 |
| Expulsion and Discipline | 18 | 31 |
| Officers | 19 | 12 |
| Term of Office—Vacancies | 20 | 13 |
| *Management.* | | |
| The Council | 21 | 14 |
| The President | 22 | 15 |
| The Treasurer | 23 | 17 |
| The Secretary | 24 | 16 |
| *Nomination and Election of Officers.* | | |
| Electoral Districts | 25 | 64 |
| List of Members | 26 | 65 |
| Election of Nominating Committee | 27 | 66 |
| Nominating Committee Meetings | 28 | 45 |
| Nominating Committee to prepare list for Officers' Ballot | 29 | 67 |
| List of Nominees for Officers sent to Members | 30 | 68 |
| Officers' Ballot | 31 | 69 |
| Canvass of Ballot | 32 | 70 |
| Letter Ballots | 33 | 71 |
| Elections | 34 | 72 |
| Appointment of Secretary, Treasurer and Committees | 35 | 18 |
| Finance Committee | 36 | 19 |
| Library and House Committee | 37 | 20 |
| Papers Committee | 38 | 21 |
| Publication Committee | 39 | 22 |
| Legislation Committee | 40 | 23 |
| Committee on Association Affairs | 41 | .. |
| Adoption of Specifications | 42 | 24 |
| *Fees.* | | |
| Entrance Fees | 43 | 32 |
| Annual Fees | 44 | 33 |
| Schedule of Fees | 45 | 34 |
| Collection of Fees | 46 | .. |
| Compounding of Fees | 47 | 39 |
| Liability | 48 | 35 |
| Liability | 49 | 36 |
| Arrears and Exemptions | 50 | 37 |
| Life Membership | 51 | 37 |
| Transfer Fee | 52 | 38 |
| Re-Admission | 53 | 40 |
| *Meetings.* | | |
| Annual General Meeting | 54 | 41 |
| Special General Meetings | 55 | 43 |
| General Professional Meetings | 56 | 43 |
| Meetings of Council | 57 | 44 |
| Meetings of Standing Committees | 58 | 46 |
| Presiding Officer | 59 | 47 |
| Branches | 60 | 48 |
| Branch Membership | 61 | 49 |
| Financial Responsibility | 62 | 50 |
| Management | 63 | 51 |
| Sections of Branches | 64 | 52 |
| By-laws | 65 | 53 |
| Functions | 66 | 54 |
| Annual Report | 67 | 55 |
| Revenue | 68 | 56 |
| General | 69 | 57 |
| Provincial Divisions | 70 | 58 |
| Management | 71 | 59 |
| Officers | 72 | 60 |
| By-laws | 73 | 61 |
| Reports | 74 | 62 |
| General | 75 | 63 |
| Journal of The Institute | 76 | 73 |
| Journal of The Institute | 77 | 74 |
| Amendments | 78 | 75 |

For Appendix "C" see The Engineering Journal, December, 1936, page 555.

For Appendix "D" see The Engineering Journal, December, 1936, page 555.

## APPENDIX "E"

### PROPOSED FORM OF BALLOT

| | Yes | No. |
|---|---|---|
| 1. Proposals for the revision of the By-laws of The Institute as submitted by the Committee on Consolidation and agreed to by the Council, exclusive of Sub-Section 7 (*b*). | | |
| 2. Revisions to the By-laws as proposed by the Council and not directly related to Consolidation. | | |
| 3. Sub-Section 7 (*b*) as submitted by the Committee on Consolidation. | I am in favour of this form of Sub-Section 7 (*b*). | |
| 4. Sub-Section 7 (*b*) as amended by the Council. | I am in favour of this form of Sub-Section 7 (*b*). | |

# Branch Reports

## Border Cities Branch

The President and Council:—

The Executive committee of the Border Cities Branch submits the following report for the calendar year 1936.

The Executive committee met six times during the year for the transaction of Branch business.

Including the annual meeting eight regular meetings and one special meeting were held.

The following is a list of the meetings held together with a note on the subject, speaker, and attendance:—

1936

Jan. 17.—**Welding High Pressure Piping** by S. Crocker and D. H. Corey, engineers for the Detroit Edison Company, Detroit. Attendance 27.

Feb. 14.—**Impressions of Portugal** by C. M. Goodrich, M.E.I.C., chief engineer for Canadian Bridge Company, Walkerville, Ontario. Attendance 24.

Mar. 20.—**Modern Problems in Railroad Engineering** by T. H. Jenkens, A.M.E.I.C., of the Grand Trunk Western R.R. Co., Detroit. Attendance 20.

April 24.—**Mining Development in Canada** by A. D. R. Fraser, of the Windsor Vocational School. Attendance 22.

May 26.—**Performance Limits of the Four Cycle Engine** by R. Janeway, of the Chrysler Motor Corporation, Detroit. Attendance. 30.

Sept. 21.—**Consolidation of the Engineering Profession in Canada** by J. F. Plow, A.M.E.I.C., Assistant to the Secretary of The Engineering Institute of Canada. Attendance 24.

Oct. 17.—Joint Meeting with the Border Cities Chapter, Ontario Association of Architects on the occasion of the Annual Meeting of the President and Council of the Association of Architects. Attendance 20.

Nov. 27.—**Drop Forgings** by R. E. Waldron, chief engineer for The Dominion Forge and Stamping Co., Walkerville, Ontario. Attendance 25.

Dec. 11.—Annual Meeting and Election of Officers. **Reminiscences in Engineering** by W. H. Baltzell, M.E.I.C., chief engineer for the Canadian Steel Corporation, Ojibway, Ont. Attendance 30.

The average attendance at the regular meetings was 25.

MEMBERSHIP

The membership of the Branch is made up as follows:—

| | *Resident* | *Non-Resident* | *Total* |
|---|---|---|---|
| Members | 12 | 3 | 15 |
| Associate Members | 32 | 6 | 38 |
| Juniors | 4 | 2 | 6 |
| Students | 8 | 6 | 14 |
| Affiliates | 1 | .. | 1 |
| | 57 | 17 | 74 |

A comparison of our present membership with that of other year is shown in the following table:—

| | *1932* | *1933* | *1934* | *1935* | *1936* |
|---|---|---|---|---|---|
| Members | 21 | 17 | 14 | 10 | 15 |
| Associate Members | 42 | 34 | 32 | 35 | 38 |
| Juniors | 8 | 5 | 3 | 3 | 6 |
| Students | 11 | 11 | 13 | 11 | 14 |
| Affiliates | 1 | 1 | 1 | 1 | 1 |
| | 83 | 68 | 63 | 60 | 74 |

FINANCIAL STATEMENT

*Receipts*

| | | |
|---|---|---|
| Balance on hand, January 1st, 1936 — This includes $24.32 unemployment fund. | $163.63 | |
| Rebates on dues for October, November and December, 1935 | 8.10 | |
| Rebates on dues for January, February, March and April, 1936 | 99.00 | |
| Rebates on dues for May, June, July, August and September, 1936 | 10.80 | |
| Rebates on dues for October, November and December, 1936 | 10.80 | |
| Dinner receipts | 62.40 | |
| | | $354.73 |

*Expenditures*

| | | |
|---|---|---|
| Printing and stamps | $ 35.40 | |
| Meals | 87.55 | |
| Speakers | 5.43 | |
| Miscellaneous | 30.53 | |
| Balance on hand in bank — This includes $24.32 unemployment fund. | 185.02 | |
| Accounts receivable, rebates, October, November, and December, 1936 | 10.80 | |
| | | $354.73 |

Respectfully submitted,

THOS. H. JENKINS, A.M.E.I.C., *Chairman.*
BOYD CANDLISH, A.M.E.I.C., *Secretary-Treasurer.*

## Calgary Branch

The President and Council:—

On behalf of the Executive committee of the Calgary Branch we have the honour to submit this report covering the activities of the Calgary Branch for the year 1936:—

MEMBERSHIP

| | *Branch Resident* | | *Branch District* | | *Total* | |
|---|---|---|---|---|---|---|
| | *1935* | *1936* | *1935* | *1936* | *1935* | *1936* |
| Members | 17 | 17 | 3 | 5 | 20 | 22 |
| Associate Members | 43 | 48 | 10 | 10 | 53 | 58 |
| Juniors | 6 | 6 | 1 | 1 | 7 | 7 |
| Students | 9 | 13 | 1 | 4 | 10 | 17 |
| Affiliates | 8 | 6 | .. | .. | 8 | 6 |
| Total | 83 | 90 | 15 | 20 | 98 | 110 |

We regret to report the death of J. H. Walshaw, A.M.E.I.C., which occurred on September 16th, 1936. We also regret the resignation of M. P. Bridgland, M.E.I.C., and E. F. Pullen, A.M.E.I.C., who have both been associated with the Calgary Branch for several years.

MEETINGS

During the year the Branch Executive committee held nine meetings for the purpose of conducting the business of the Branch. The various sub-committees held meetings as required for the carrying on of their work.

Twelve general and special meetings of the Branch were held during the year. Pertinent data of these meetings is shown by the following summary:—

1936

Jan. 16.—Branch General Meeting, T. Lees, M.E.I.C., on Steel Rails. Attendance 38.

Jan. 30.—Branch General Meeting, Mr. A. Calhoun, Librarian, Calgary Public Library, on The Engineer and Society. Attendance 29.

Feb. 13.—Branch General Meeting, Mr. R. J. Stringer, Branch Affiliate, on **Diesel Engines.** Attendance 38.

Feb. 27.—Branch General Meeting. The speaker was Mr. W. Pratt, District Manager, Otis-Fensom Elevator Co., Ltd., and films also were shown. Attendance 55.

Mar. 14.—Branch Annual Meeting, A. Griffin, A.M.E.I.C., spoke on the **Annual Meeting of The Institute**, Hamilton, February 5th, 6th and 7th, 1936. Attendance 31.

Mar. 21.—Joint Dinner with Association of Professional Engineers of Alberta and Rocky Mountain Branch Canadian Institute of Mining and Metallurgy. Total attendance 109.

June 11.—Branch Special Meeting, Mr. P. E. Biggar on **Diesel Engines.** Attendance 65.

Aug. 29.—Annual Golf Tournament held at Strathmore Golf Course. Attendance 30.

Sept. 25.—Branch Special Meeting, Dr. E. A. Cleveland, M.E.I.C., President of The Institute spoke on **Problems of The Institute.** Attendance 30.

Oct. 20.—Branch General Meeting, Mr. J. E. A. Macleod, K.C., gave a talk on **Early Western Travel and Travel Ways.** Attendance 34.

Nov. 5.—Branch General Meeting at which a number of films were shown. Attendance 126.

Nov. 27.—Annual Dance held at Renfrew Club. Attendance 60.

Dec. 8.—Branch General Meeting, Mr. C. A. Choate, instructor, Provincial Institute of Technology and Art, Calgary, spoke on **The Evolution of the Motor Car.** Attendance 28.

The average attendance at Branch General Meetings was 50.

### Supplementary Report Regarding Employment Conditions in Calgary Branch Territory

The situation regarding employment of engineers in this district has improved only slightly in the year 1936. This slight improvement is due to employment of engineers on government projects and to increased activity in the Turner Valley oil fields. Several members of this Branch, including experienced engineers as well as recent graduates, are unemployed and the present prospects do not indicate any material betterment of this condition in the immediate future.

### Financial Statement

*Revenue*

| | | |
|---|---|---|
| Rebates from membership fees:— | | |
| January to September incl. | $168.75 | |
| October to December incl. | 17.40 | |
| Affiliates dues | 18.00 | |
| Interest and savings | 41.07 | |
| Sale of bonds | 206.29 | |
| | 451.51 | |
| Deficit | 1.74 | |
| | | $453.25 |

*Expenditure*

| | | |
|---|---|---|
| Branch General Meetings | $ 58.27 | |
| Golf tournament | 17.41 | |
| Deficit re Annual Dance | 23.40 | |
| Rent of safety deposit box | 3.00 | |
| Branch Annual Meeting | 19.05 | |
| Expenses re Plenary Meeting of Council, October 16-17, 1936 | 28.50 | |
| Secretary's expenses | 29.29 | |
| Printing booklet of Branch By-laws and List of Members | 27.23 | |
| Joint Dinner with A.P.E. and C.I.M. & M. | 30.00 | |
| Miscellaneous expenses | 7.47 | |
| Purchase of bond | 209.63 | |
| | | $453.25 |

### Financial Statement as at December 31st, 1936

| | | |
|---|---|---|
| Cash in bank as at December 31st, 1935 | $140.26 | |
| Rebates—October, November and December, 1935. | 20.70 | |
| Balance as at December 31st, 1935 | | $160.96 |
| Deficit on operation 1936 as per statement of Revenue and Expenditure | | 1.74 |
| Balance as at December 31st, 1936 | | $162.70 |

### Balance Sheet as at December 31st, 1936

*Assets*

| | | |
|---|---|---|
| Bank balance as at December 31st, 1936 | $141.82 | |
| Rebates—October to December incl., 1936 | 17.40 | |
| Book value of securities as at December 31st, 1936 | 953.82 | |
| Total assets | | $1,113.04 |

*Liabilities*
None.

Audited and found correct,
R. W. Dunlop, A.M.E.I.C., Auditor.

Respectfully submitted,
John Dow, M.E.I.C., *Chairman.*
James McMillan, A.M.E.I.C., *Secretary-Treasurer.*

## Cape Breton Branch

The President and Council:—

The Cape Breton Branch held four meetings during the year as under:—

1936

Feb. 18.—Annual Meeting and Banquet.

Mar. 3.—Talk by E. L. Ganter of Canadian General Electric Co., on **Development of Electricity in Canada and Applications of Electricity in the Home.** Illustrated.

Mar. 18.—Paper by R. S. Eadie, M.E.I.C., of Dominion Bridge Co., on **Steel-Concrete Composite Construction.** Illustrated.

Nov. 7.—Discussions by Vice-President H. W. McKiel, M.E.I.C., on **Consolidation of Engineering Organizations** and on **Engineering Education.**

The average attendance at these meetings was 32.

The financial statement is as below:—

*Receipts*

| | | |
|---|---|---|
| Brought forward | $219.84 | |
| Rebates from Headquarters | 102.30 | |
| Annual Meeting | 36.00 | |
| | | $358.14 |

*Expenditures*

| | | |
|---|---|---|
| Meetings | $126.79 | |
| Telegrams | 1.89 | |
| Wreath | 10.00 | |
| Secretarial expenses | 13.20 | |
| Balance on hand | 206.26 | |
| | | $358.14 |

Respectfully submitted,
Sydney C. Mifflen, M.E.I.C., *Secretary-Treasurer.*

## Edmonton Branch

The President and Council:—

On behalf of the Executive committee of the Edmonton Branch we wish to submit the following report for the year 1936:—

### Membership

Our present membership is as follows:—

| | *Resident* | *Non-Resident* | *Total* |
|---|---|---|---|
| Members | 18 | 2 | 20 |
| Associate Members | 25 | 6 | 31 |
| Juniors | 6 | 2 | 8 |
| Students | 28 | .. | 28 |
| | 77 | 10 | 87 |

This shows an increase of 14 members over the 1935 membership.

### Meetings

The Executive committee held four meetings during the year to transact the business of the Branch.

The Branch held six general meetings through the year. The following is a summary:—

1936

Feb. 4.—Dinner and Meeting at Macdonald hotel, addressed on **Treatment of Water** by Alex Ritchie, A.M.E.I.C., acting superintendent of City of Edmonton Power Plant.

Feb. 27.—Dinner and Meeting at Macdonald hotel, addressed by Julian Garrett, M.E.I.C., on **The Use of Temperature Statistics in the Gas Business.**

Mar. 25.—Dinner and Meeting at the University of Alberta. Election of officers for 1936-37 Session, and inspection of the Civil Engineering Laboratories and University Power Plant.

April 24.—Dinner and Meeting at the Corona hotel. This was the annual mixed meeting of the Branch when the members entertained their wives and friends. Mr. John Blue, Secretary, Edmonton Chamber of Commerce, gave an address on **The Odyssey of the North.**

Nov. 10.—Inspection of Canada Packers Plant, followed by dinner and meeting at Corona hotel, addressed by Mr. C. J. Long, plant superintendent, on **Processing and Equipment.**

Dec. 15.—Dinner, followed by debate, at Macdonald hotel, on **"Resolved that the Railways are a Moribund Form of Transportation."** R. J. Gibb, M.E.I.C., was leader for the affirmative, with R. W. Ross, A.M.E.I.C., leader for the negative.

FINANCIAL STATEMENT

*Receipts*

| | | | |
|---|---|---|---|
| Balance in bank, December 31st, 1935... | $128.70 | | |
| Rebates—October, November and December, 1935 | 10.80 | | |
| 1935 balance | | $139.50 | |
| Rebates from Headquarters to September 30th, 1936 | | 120.60 | |
| Rebates—October, November and December, 1936 | | 20.40 | |
| | | | $280.50 |

*Expenditures*

| | | |
|---|---|---|
| Expenses of Branch meetings | $ 27.90 | |
| Postage and telegrams | 14.30 | |
| Printing | 17.32 | |
| Honorarium to Secretary-Treasurer | 50.00 | |
| Balance in bank, December 31st, 1936 | 150.58 | |
| Rebates—October, November and December, 1936 | 20.40 | |
| | | $280.50 |

*Assets*

| | | |
|---|---|---|
| Bank balance | $150.58 | |
| Rebates—October, November and December, 1936 | 20.40 | |
| | | $170.98 |

*Liabilities*

None.

Audited and found correct:

ALAN E. CAMERON
E. L. SMITH, A.M.E.I.C. } Auditors.

Respectfully submitted,

EDGAR STANSFIELD, M.E.I.C., *Chairman.*
M. L. GALE, A.M.E.I.C., *Secretary-Treasurer.*

## Halifax Branch

The President and Council:—

The year 1936 was a fairly active one in the Halifax Branch. For the first time in many years the Branch sent an official representative to the Annual Meeting of The Institute. H. S. Johnston, M.E.I.C., was the delegate and his report on the proceedings was circularized to all members of the Halifax and Sydney Branches, and as a result interest in Institute affairs was greatly stimulated in this territory.

The usual number of meetings were held as follows:—

1936

Jan.— The Annual Banquet in co-operation with the Nova Scotia Society of Professional Engineers was held at the Nova Scotian hotel and the attendance was greater than any previous banquet.

Feb.— The February meeting was addressed by Lt.-Col. J. B. Dunbar, A.M.E.I.C., A.A. and Q.M.G., Military District No. 6 Halifax, N.S., on **Some Road Construction Work in Connection with the Unemployment Relief Project at Valcartier Camp.** This paper was interesting as it dealt with the making of modern roads with primitive equipment as under the terms of the Unemployment Relief Project no machinery could be used on this work.

April.—In contrast with Col. Dunbar's paper was the one delivered by Mr. R. W. McColough, the chief engineer of the Department, of Highways, in April. Mr. McColough spoke on **The Rebuilding of the Main Trunk Highways in the Province of Nova Scotia,** describing the construction from beginning to end.

Sept.— In September, Dr. E. A. Clevcland, M.E.I.C., the President of The Institute, gave a very interesting speech dealing with the activities of The Institute.

Nov.— The November meeting was addressed by Professor G. Vibert Douglas, head of the Department of Geology at Dalhousie University, who spoke on **Geology with Respect to Metal Mining.**

The attendance and interest shown by members during the past year has shown a decided improvement and it is hoped that this will be further improved during the coming year.

During the year the Saint John Branch assisted in sponsoring a Maritime Professional Meeting at Saint John in August and the Halifax Branch was well represented, seventeen members of the Branch being present at the meeting.

EMPLOYMENT

There has been a definite improvement in employment of engineers in the province during the past year. While the work available may not be as remunerative as one would desire, still there was no reason for any trained engineer to be idle. The works programme of the Department of Highways and the development work undertaken by the power companies, especially the Nova Scotia Light and Power Co., and the increased activity of the Dominion Coal Co. absorbed all available engineers, and present indications show that there will be a scarcity of trained men during the coming year.

FINANCES

For the first time in a number of years the financial statement shows a deficit for the year's operation but there is still a substantial cash balance available. A copy of the financial statement follows:—

FINANCIAL STATEMENT

*Income*

| | | | |
|---|---|---|---|
| Rebates—January, 1936 | $ 36.42 | | |
| June, 1936 | 163.20 | | |
| November, 1936 | 44.70 | | |
| Dues | 10.00 | | |
| | | $254.32 | |
| Bank interest—May | 1.54 | | |
| November | 1.03 | | |
| | | 2.57 | |
| | | | $256.89 |

*Disbursements*

| | | | |
|---|---|---|---|
| Annual grant to Secretary | $ 50.00 | | |
| Flowers, N.S. Nurseries | 14.00 | | |
| Annual banquet grant | 72.23 | | |
| Expenses—H. S. Johnston to Annual Meeting | 104.43 | | |
| Office expenses | 77.64 | | |
| | | $318.30 | |
| Deficit for the year 1936 | | 61.41 | |
| | | | $256.89 |

*Summary*

| | | |
|---|---|---|
| Bank balance, 1935 | $477.58 | |
| Deficit, 1936 | 61.41 | |
| | | $416.17 |
| Royal Bank | $405.64 | |
| Bank of Commerce | 10.53 | |
| Balance, 1936 | | $416.17 |

Respectfully submitted,

R. R. MURRAY, A.M.E.I.C., *Secretary-Treasurer.*

## Hamilton Branch

The President and Council:—

The Executive committee of the Hamilton Branch, Engineering Institute of Canada. submits the following report for the year 1936:—

The Executive committee held seven meetings throughout the year.

MEMBERSHIP

*December 31st, 1935*

| | *Resident* | *Non-Resident* | *Total* |
|---|---|---|---|
| Members | 32 | 4 | 36 |
| Associate Members | 33 | 12 | 45 |
| Juniors | 11 | 2 | 13 |
| Students | 26 | 7 | 33 |
| Affiliates | 2 | .. | 2 |
| Branch Affiliates | 16 | .. | 16 |
| | 120 | 25 | 145 |

Also 1 Member, 4 Associate Members, and 4 Juniors on the non-active list.

*December 31st, 1936*

| | *Resident* | *Non-Resident* | *Total* |
|---|---|---|---|
| Members | 33 | 5 | 38 |
| Associate Members | 37 | 11 | 48 |
| Juniors | 11 | .. | 11 |
| Students | 30 | 6 | 36 |
| Affiliates | 2 | .. | 2 |
| Branch Affiliates | 16 | .. | 16 |
| | 129 | 22 | 151 |

Also 4 Members, 3 Associate Members, and 4 Students on the non-active list.

MEETINGS AND PAPERS

1936

Jan. 14.—Annual Business Meeting. Professional Meeting—**Air Conditioning** by J. W. Bishop of the Canadian General Electric Co. Local Chapter, Ontario Association of Architects were guests on this occasion. Attendance 100.

Mar. 26.—**Aircraft Development in Europe** by Professor T. R. Loudon, M.E.I.C., of Toronto University. Hamilton Aero Club invited to attend this meeting. Attendance 80.

April 3.—Joint Meeting with the Toronto Section, American Institute of Electrical Engineers, with the Canadian Westinghouse Co. as hosts. **Recent Electrical Developments in the Steel Industry** by R. H. Wright of the Westinghouse Electric and Manufacturing Co., Pittsburgh. Attendance 200.

May 15.—**Description of the Grand River Conservation Scheme** by E. T. Sterne of Brantford. Attendance 45.

Oct. 2.—**The Lumber Industry in British Columbia** by Archie Moore, manager, "B.C. Lumberman." Attendance 60.

Oct. 20.—**The Life and Inventions of James Watt** by Professor R. W. Angus, M.E.I.C., of Toronto University. Attendance 55.

Nov. 17.—**Heat Insulation Tests and their Value** by Professor E. A. Allcut, M.E.I.C., of Toronto University. Architects and builders' supply firms invited to hear this lecture. Attendance 80.

Dec. 8.—**Speech and Music and their Relation to Transmission Problems** by D. G. Geiger, A.M.E.I.C., of the Bell Telephone Co. of Canada, Toronto. Attendance 70.

W. J. W. Reid, A.M.E.I.C., chairman of the Meetings and Papers committee, has once again discharged his duties efficiently and acceptably and is to be congratulated on the speakers he has secured. The attendance at meetings is ample evidence of the interest aroused.

An appeal was made for Students and Juniors to submit papers for competition, but the response was so disappointing that it was decided to withdraw the contest for 1936.

With the exception of one meeting held in the Canadian Westinghouse Co. auditorium, all the meetings were held in the Chemistry Lecture Room at McMaster University and the Executive would, once again, place on record their indebtedness to the authorities of McMaster University for their kindness in extending to the Branch the privilege of meeting there.

INSTITUTE ANNUAL GENERAL AND PROFESSIONAL MEETING

Sponsored by the Hamilton Branch, the Annual Meeting of The Institute was held in the Royal Connaught hotel, February 5th, 6th and 7th, with a total registration of 335 men and 77 ladies. In addition to the usual business, professional and social functions, which were all well attended, February 5th saw three business sessions in connection with the work of The Institute Committee on Consolidation.

PUBLICITY

The Executive committee acknowledge the courtesies extended by the "Hamilton Spectator," particularly in connection with The Institute Annual Meeting.

OBITUARY

During the year, the Branch lost a very valued supporter in the passing of H. U. Hart, M.E.I.C., a Past-Chairman of the Branch. Mr. Hart devoted much time and energy to Branch affairs and as recently as The Institute Annual Meeting rendered outstanding service.

FINANCIAL STATEMENT

*Income*

| | | |
|---|---|---|
| Bank balance, January 1st, 1936 | $121.03 | |
| Cash on hand, January 1st, 1936 | 5.00 | |
| From Headquarters, due for 1935 | 9.90 | |
| Branch Affiliates fees | 48.00 | |
| Rebates on fees | 226.20 | |
| Annual Meeting comm. | 65.59 | |
| National Sewer Pipe Co | 50.00 | |
| Interest | 58.47 | |
| | | $584.19 |

*Expenditure*

| | | |
|---|---|---|
| Printing and postage | $ 76.53 | |
| Meeting expenses | 125.50 | |
| Stenographer | 50.00 | |
| Sundry | 11.51 | |
| Travelling expenses | 62.46 | |
| Students' prizes | 25.00 | |
| Balance in bank | 231.99 | |
| Due from Headquarters | 1.20 | |
| | | $584.19 |

| | |
|---|---|
| Net income | $456.96 |
| Net expenditure | 351.50 |
| Net operating surplus | $105.46 |

*Assets*

| | | |
|---|---|---|
| Bonds at cost | $915.00 | |
| Lantern, less depreciation | 75.00 | |
| Bank balance | 231.99 | |
| Due from Headquarters | 1.20 | |
| | | $1,223.19 |

Respectfully submitted,
W. HOLLINGWORTH, M.E.I.C., *Chairman*
ALEX. LOVE, M.E.I.C., *Secretary-Treasurer.*

## Kingston Branch

The President and Council:—

During the year 1935-1936 the Kingston Branch met six times as follows:—

1935

Oct. 31.—Annual Meeting, for the presentation of reports and election of officers.

Dec. 4.—J. L. Busfield, M.E.I.C., gave a talk on **The Development of the High Speed Diesel Engine with Special Reference to Automotive Work.** Nineteen were present at the meeting and seventeen at the preceding dinner. Mr. Busfield gave a very interesting discussion of the present stage of Diesel development, and illustrated his remarks with a number of excellent slides.

1936

Jan. 17.—Commander A. D. M. Curry, M.E.I.C., presented his paper entitled **From Sail to Steam in the Royal Navy.** Twenty-one were present at the dinner and meeting, and the paper was very much appreciated.

Jan. 30.—Professor J. K. Robertson, Queen's University, gave a lecture on **Some Modern Concepts of Physics.** The lecture, which was well illustrated, dealt with recent discoveries and theories as to the structure of the atom. Eighteen were present.

Feb. 27.—Professor L. T. Rutledge, M.E.I.C., presented a paper entitled **Film Lubrication.** A discussion of the principles of lubrication and the factors affecting it. Well illustrated with slides and with samples of lubricating oils. Dealt with the results of the most recent research. Eighteen present.

Sept. 29.—A dinner and general meeting of the Branch was held for the report of Dr. L. F. Goodwin, M.E.I.C., Branch Councillor, on the progress of the Committee on Consolidation, and to consider certain other business.

EMPLOYMENT

The Branch was able to assist one member in finding suitable employment during the past year.

CHAMBER OF COMMERCE

No meetings of the Chamber of Commerce have dealt with questions in which the Branch, as such, is concerned.

MEMBERSHIP

The membership for the past five years is given below:—

| | Honorary Members | Members | Associate Members | Juniors | Students |
|---|---|---|---|---|---|
| 1931-32 | 1 | 12 | 17 | 6 | 7 |
| 1932-33 | 1 | 13 | 16 | 6 | 16 |
| 1933-34 | 1 | 11 | 19 | 7 | 14 |
| 1934-35 | 1 | 11 | 18 | 3 | 13 |
| 1935-36 | 1 | 12 | 18 | 4 | 11 |

FINANCIAL STATEMENT

*Receipts*

| | | |
|---|---|---|
| Balance forward | $ 48.87 | |
| Nov. 13—Rebates | 12.90 | |
| Dec. 4—Dinner | 1.15 | |
| Jan. 29—Rebates | 9.90 | |
| June 29—Rebates | 66.90 | |
| Interest | .56 | |
| | | $140.28 |

*Expenditures*

| | | |
|---|---|---|
| Postage and telegrams | $ 2.16 | |
| Printing, etc | 12.53 | |
| Dinners | 9.15 | |
| Speakers expenses | 12.90 | |
| Secretary | 25.00 | |
| Chamber of Commerce | 15.00 | |
| Bank balance | 63.54 | |
| | | $140.28 |

*Assets*

| | | |
|---|---|---|
| Bank balance | $ 63.54 | |
| Note | 50.00 | |
| | | $113.54 |

*Liabilities*

| | | |
|---|---|---|
| Owing to E.I.C. | $ 50.00 | |
| Surplus | 63.54 | |
| | | $113.54 |

Respectfully submitted,
L. F. GRANT, M.E.I.C., *Secretary-Treasurer.*

## Lakehead Branch

The President and Council:—

On behalf of the Executive committee of the Lakehead Branch we beg to submit the following report for the year 1936:—

During the year ten regular meetings and five Executive meetings were held. Of the regular meetings five were held in Port Arthur, four in Fort William and one at Kakabeka Falls.

The list of monthly meetings are as follows:—

1936

Jan. 22.—Dinner meeting at which R. F. Legget, A.M.E.I.C., gave an address on **Steel Piling.**

Feb. 18.—Meeting at the mill of The Provincial Paper Co. Dinner was held in the restaurant of the mill, and after a brief description of the plant the members were taken through the mill in small groups headed by members of the staff.

Mar. 18.—Dinner meeting. Illustrated lecture by Mr. J. M. Murie on **Electric Arc Welding.**

April 23.—Annual Meeting at which officers for the year were elected. The guest speaker was Mr. F. V. Siebert. Representatives of other professions were guests.

May 13.—Dinner meeting at which P. L. Pratley, M.E.I.C., gave an illustrated lecture on **The Isle D'Orleans Bridge.**

Sept. 16.—Dinner meeting at Kakabeka Falls at which Mr. W. L. Bird gave a short sketch of the history of the plant of the Kaministiquia Power Co., after which the members were conducted through the plant.

Sept. 23.—Meeting at which J. L. Rannie, M.E.I.C., gave an interesting lecture on **Geodetic Surveying.**

Oct. 21.—Dinner meeting at which Mr. Erle Smith gave a talk on roads in the district.

Nov. 18.—Dinner meeting devoted to business.

Dec. 10.—Dinner meeting at which members and guests heard an interesting lecture on building construction by W. H. Greene, A.M.E.I.C. Guests of the evening were lumber merchants, architects and those interested in the use of lumber.

### Employment of Engineers

Regarding employment at the Head of the Lakes we might say that we have been extremely fortunate.

As far as we know all the engineers of the Branch have been employed for the greater part of the year. Some of this work was only temporary but little difficulty was had in placing engineers. Several engineers were brought in from outside districts. Remuneration has not yet reached a satisfactory level.

This Branch had only one case in which financial aid was necessary. This was the case of an aged transient engineer who was provided for until work was obtained for him in the mining area.

### Financial Statement

*Receipts*

| | | |
|---|---|---|
| Balance in bank at December 31st, 1935 | $259.53 | |
| Rebates—October to December, 1935 | 12.30 | |
| Cash on hand, December 31st, 1935 | 13.44 | |
| Rebates from Headquarters:— | | |
| January to April incl | 73.20 | |
| May to September incl | 23.10 | |
| October to December incl | 9.90 | |
| Bank interest | 1.58 | |
| Receipts from collections | 107.80 | |
| Refund from Councillor Plenary Meeting | 150.00 | |
| Balance cash account | 1.93 | |
| | | $652.78 |

*Expenditures*

| | | |
|---|---|---|
| Expenses of meetings | $218.55 | |
| Telegrams | 1.65 | |
| Stationery | .60 | |
| Postage and excise stamps | 6.37 | |
| Mimeographing | 1.95 | |
| Donation—Travelling expense to Geraldton, Mr. Hunter | 5.00 | |
| Balance in bank, December 31st, 1936 | 258.76 | |
| Rebates due, October to December, 1936 | 9.90 | |
| Advance to Councillor Plenary Meeting | 150.00 | |
| | | $652.78 |

Respectfully submitted,

Frank C. Graham, A.M.E.I.C., *Chairman.*

G. R. McLennan, A.M.E.I.C., *Secretary-Treasurer.*

## Lethbridge Branch

The President and Council:—

The following is a report of the operations of the Lethbridge Branch, Engineering Institute of Canada, for the year 1936.

Since January 1st, 1936, nine regular meetings with an average attendance of 44, two corporate members meetings, average attendance 12, and seven executive meetings, average attendance 7, were held.

The Entertainment committee have worked very hard and as a result the social side of our programmes have been excellent. All regular meetings have been held in the Marquis hotel, preceded by a dinner during which numbers were rendered by Geo. Brown's instrumental quartette, followed by vocal solos and community singing.

The list of speakers and subjects chosen follows:—

1936

Jan. 25.—Motion picture films. **Building the 8000 Locomotive,** Mr. E. J. Lemieux, division master mechanic, Canadian Pacific Railway, Lethbridge. Attendance 40.

Feb. 8.—Thomas Lees, M.E.I.C., District Engineer, Canadian Pacific Railway, Calgary, on **Some Observations of Railway Rails.** Attendance 28.

Mar. 7.—Joint meeting of the Lethbridge Branch, Engineering Institute of Canada, with the Professional Engineers of Alberta. Attendance 45.

Mar. 14.—Motion pictures and lantern slides. Speaker: P. F. Peele, A.M.E.I.C., Canadian General Electric Co., Calgary who talked on **Electron Tubes.** Attendance 30.

Sept. 25.—Dr. E. A. Cleveland, M.E.I.C., President of The Engineering Institute of Canada, on **Institute Affairs.** Attendance 25.

Oct. 10.—Air Commodore H. Hollick-Kenyon who gave an address on **The Ellsworth Antarctic Expedition.** Ladies as guests. Attendance 53.

Oct. 17.—Inspection trip to Lethbridge Collieries Ltd. Galt Mine No. 8. Wm. Meldrum, A.M.E.I.C., mines engineer, Lethbridge Collieries Ltd., Lethbridge, who spoke on **Galt Mines Fourth Venture.**
Mr. E. J. Carlyle, General Secretary, Institute of Mining and Metallurgy, Montreal, on **One Troy Ounce of Gold.** Attendance 32.

Nov. 21.—Inspection trip to the Canadian Sugar Factories Ltd. plant at Picture Butte. Mr. F. H. Ballou, chief engineer, Canadian Sugar Factories Ltd., on **The Manufacture of Beet Sugar.** Attendance 90.

Dec. 5.—Ladies Night, Musical Programme, Bridge. Major F. G. Cross, M.E.I.C., Superintendent Operation and Maintenance, C.P.R., D.N.R., Lethbridge, who spoke on **The Artist and the Engineer.** Attendance 52.

The annual meeting of the Branch was held on March 14th, 1936, the officers being elected for the 1936-1937 season.

At December 31st, 1936, the membership of the Branch stood as follows:—

| | *Resident* | *Non-Resident* | *Total* |
|---|---|---|---|
| Members | 4 | .. | 4 |
| Associate Members | 15 | 7 | 22 |
| Juniors | .. | 5 | 5 |
| Students | 4 | 5 | 9 |
| Affiliates | 27 | .. | 27 |
| | 50 | 17 | 67 |

There is no unemployment among the members of the Lethbridg Branch, Engineering Institute of Canada, according to data obtaine from the local Committee on Unemployment.

### Financial Statement

*Receipts*

| | | |
|---|---|---|
| Rebates received from Headquarters for January to April incl | $ 48.90 | |
| Rebates received from Headquarters for May to September incl | 11.85 | |
| Branch Affiliate fees and Journal subscriptions | 58.15 | |
| Rent of motion picture projector | 5.00 | |
| Total revenue | $123.90 | |
| Bank balance as at December 31st, 1935 | 12.54 | |
| Total receipts | $136.44 | |
| Rebates due from Headquarters for October to December incl | 2.70 | |
| | | $139.14 |

*Expenditures*

| | | |
|---|---|---|
| Printing and stationery | $ 35.10 | |
| Meeting expenses (dinners, music, etc.) | 45.60 | |
| Headquarters—Branch Affiliate Journal subscriptions | 12.15 | |
| Orchestra | 15.00 | |
| Postage, exchange, flowers, etc | 17.04 | |
| | | $124.89 |

*Assets*

| | | |
|---|---|---|
| Bank balance as at December 31st, 1936 | $ 11.55 | |
| Holmes projector (value $360.25, less 60% depreciation) | 144.10 | |
| | | $155.65 |

*Liabilities*

Nil.

We have examined the books, papers, vouchers and the foregoing statement prepared by the Secretary-Treasurer and find the same to be a true and correct account of the standing of the Branch.

C. S. Donaldson, A.M.E.I.C. }
G. S. Brown, A.M.E.I.C. } Auditors.

Respectfully submitted,

E. A. Lawrence, S.E.I.C., *Secretary-Treasurer.*

## London Branch

The President and Council:—

During the year 1936 the following meetings were held:—

1936

Jan. 29.—Annual Meeting with Capt. T. F. Williams, instructor at the London Flying Club, as guest speaker. Attendance 26.

Feb. 20.—Illustrated lecture by R. C. Manning, engineer of the Canadian Institute of Steel Construction, on **Steel Industry in Canada.** Attendance 21.

Mar. 26.—Talk by J. S. Milligan on **The New Canadian Home,** illustrated by slides showing new type of house construction introduced by Pigott Construction Co. of Hamilton. Attendance 66.

April 22.—Social evening at home of Councillor J. A. Vance, A.M.E.I.C., of Woodstock; speaker, W. G. Ure on **Calendar Reform.** Attendance 25.

May 28.—Address by E. C. Neville, Bridge and Building Master, C.N. Railways, on **Underwater Inspection of Bridge Structures.** Attendance 16.

July 25.—Tour of inspection through New Dominion Public Building, London, and J. Labatt's Brewery. Attendance 40.

Sept. 19.—Tour of inspection through Kellogg Co. plant, London. Attendance 35.

Sept. 22.—Dinner Meeting to meet J. F. Plow, A.M.E.I.C., of the Headquarters Staff of The Institute. Attendance 13.

Oct. 3.—Tour of inspection through Silverwood's Ltd. plant, London. Attendance 14.

Oct. 20.—Lecture by W. O. LeBere of C.N. Railways on **Safety in the Erection of Steel.** Attendance 15.

Nov. 25.—Talk by Councillor J. A. Vance on points raised and discussed at Plenary Meeting in Montreal. Attendance 10

Average attendance of all meetings 25.

In addition to above, five Executive meetings were held with an average attendance of 6.6.

Financial Statement

*Receipts*

| | | |
|---|---|---|
| Cash on hand, January 1st, 1936 | $ 3.10 | |
| Bank balance | 138.90 | |
| Rebates from Headquarters for 1935 | 12.90 | |
| Rebates from Headquarters for 1936 | 96.30 | |
| Annual dinner, 1936 | 13.50 | |
| "Plow" dinner meeting | 13.00 | |
| Rebates due from Headquarters for October to December 1936 | 3.90 | |
| | | $281.60 |

*Expenditures*

| | | |
|---|---|---|
| Annual dinner expenses | $ 45.61 | |
| 1935 Secretary's expenses, January 1st to January 31st, 1936 (S. G. Johre) | 1.23 | |
| Stenographer for 1935 | 5.00 | |
| Printing | 34.70 | |
| New sheets for Minute Book | 1.62 | |
| Hotel London for Plow dinner | 13.00 | |
| Secretary, for 2 dinners and entertainment on occasion of Mr. Plow's visit | 2.69 | |
| Flowers—D. S. Scrymgeour | 3.25 | |
| Rent of hall and elevator service for regular meetings | 9.00 | |
| Secretary's expenses, stamps, etc | 5.18 | |
| | $121.28 | |
| Cash on hand, December 31st, 1936 | 1.87 | |
| Bank balance, December 31st, 1936 | 154.55 | |
| Rebates due from Headquarters for October to December, 1936 | 3.90 | |
| | | $281.60 |

Respectfully submitted,

James Ferguson, A.M.E.I.C., *Chairman.*

D. Stuart Scrymgeour, A.M.E.I.C., *Secretary-Treasurer.*

## Moncton Branch

The President and Council:—

On behalf of the Executive committee we beg to submit the seventeenth annual report of Moncton Branch.

The Executive committee held seven meetings. Six meetings of the Branch were held, at which addresses were given and business transacted as follows:—

1936

Feb. 28.—A meeting was held in the City Hall. Professor H. W. McKiel, M.E.I.C., delivered an illustrated address on **Domestic Air Conditioning.**

Mar. 13.—A meeting was held in the City Hall. R. S. Eadie, A.M.E.I.C., of Dominion Bridge Company, Montreal, gave an illustrated address on **Steel-Concrete Composite Construction.**

Mar. 20.—A meeting was held in the City Hall. Dr. H. E. Bigelow, Professor of Chemistry, Mount Allison University, read a paper on **National Problems for Research in Canada.**

May 8.—A meeting was held for the purpose of nominating Branch officers for 1936-37.

May 29.—The annual meeting of the Branch was held on this date.

Aug. 31.—A luncheon meeting was held at the Riverdale Golf Club. Dr. E. A. Cleveland, M.E.I.C., President of The Engineering Institute of Canada, addressed the meeting on **Institute Affairs.**

Membership

Our membership at present consists of sixty members, as follows:—

| | *Resident* | *Non-Resident* |
|---|---|---|
| Members | 5 | 1 |
| Associate Members | 19 | 7 |
| Juniors | 3 | 2 |
| Students | 6 | 9 |
| Affiliates | 8 | .. |
| | 41 | 19 |

Financial Statement

*Receipts*

| | | |
|---|---|---|
| Balance in bank, January 1st, 1936 | $111.02 | |
| Cash on hand, January 1st, 1936 | 6.22 | |
| Rebates on dues | 78.90 | |
| Affiliate dues | 35.00 | |
| Tickets sold for luncheon meeting | 9.00 | |
| Bank interest | .85 | |
| Rebates due from Headquarters | 6.00 | |
| | | $246.99 |

*Expenditures*

| | | |
|---|---|---|
| Expenses of meetings | $ 13.80 | |
| Postage | 7.00 | |
| Telegrams and telephones | 2.72 | |
| Red Cross, Moose River Relief Fund | 25.00 | |
| Honorarium to Secretary | 25.00 | |
| Miscellaneous | 31.35 | |
| Balance in bank | 134.27 | |
| Cash on hand | 1.85 | |
| Rebates due from Headquarters | 6.00 | |
| | | $246.99 |

*Assets*

| | | |
|---|---|---|
| Balloptican lantern | $ 30.00 | |
| Motion picture equipment | 85.00 | |
| Attache case | 5.00 | |
| Unpaid Affiliate dues | 5.00 | |
| Cash in bank | 134.27 | |
| Cash on hand | 1.85 | |
| Rebates due from Headquarters | 6.00 | |
| | | $267.12 |

*Liabilities*

None.

Audited and found correct,
James Pullar, A.M.E.I.C. }
R. H. Emmerson, A.M.E.I.C. } Auditors.

Respectfully submitted,

G. L. Dickson, A.M.E.I.C., *Chairman.*

V. C. Blackett, A.M.E.I.C., *Secretary-Treasurer.*

## Montreal Branch

On behalf of the Executive Committee we have the honour to submit the annual report for the year 1936, the nineteenth session.

The Executive Committee consists of the following members:—

Officers

Chairman .......... J. B. D'Aeth, M.E.I.C.
Vice-Chairman .......... H. Massue, A.M.E.I.C.
Secretary-Treasurer .......... C. K. McLeod, A.M.E.I.C.

Committee

Past Chairman .......... F. S. B. Heward, A.M.E.I.C.

*Elected Members of Committee*

| | |
|---|---|
| R. H. Findlay, M.E.I.C. | J. A. E. Gohier, M.E.I.C. |
| J. A. Lalonde, A.M.E.I.C. | C. C. Lindsay, A.M.E.I.C. |
| B. R. Perry, M.E.I.C. | T. C. Thompson, A.M.E.I.C. |

*Ex-Officio Members of the Committee*

| | |
|---|---|
| O. O. Lefebvre, M.E.I.C. | A. Cousineau, A.M.E.I.C. |
| F. P. Shearwood, M.E.I.C. | A. Frigon, M.E.I.C. |
| C. B. Brown, M.E.I.C. | F. Newell, M.E.I.C. |
| E. A. Ryan, M.E.I.C. | P. L. Pratley, M.E.I.C. |

Officers of Committees

| *Committee* | *Chairman* | *Vice-Chairman* |
|---|---|---|
| Papers and Meetings | B. R. Perry, M.E.I.C. | K. O. Whyte, A.M.E.I.C. |
| Membership | T. C. Thompson, A.M.E.I.C. | |
| Admission | C. C. Lindsay, A.M.E.I.C. | E. Gohier, M.E.I.C. |
| Reception and Entertainment | R. H. Findlay, M.E.I.C. | |
| Nomination | J. A. Lalonde, A.M.E.I.C. | |
| Publicity | J. M. Fairbairn, A.M.E.I.C. | |
| Unemployment | J. A. McCrory, M.E.I.C. | E. A. Ryan, M.E.I.C. |
| Town Planning | Leonard Schlemm, M.E.I.C. | J. A. Lalonde, A.M.E.I.C. |
| Finance | J. B. D'Aeth, M.E.I.C. | C. K. McLeod, A.M.E.I.C. |

### Membership Committee

During the year the Membership Committee has done valuable work in listing the Members of the branch according to various fields of Engineering in which they are engaged, also, a list has been made showing the non-active Members, and another of persons removed from membership. These lists, we believe, will be of great value to future Membership Committees.

A committee consisting of eight members under the leadership of the Chairman are endeavouring to again interest many of the ex-members and qualified Engineers to join The Institute. The practical result of their labours is indicated by the membership roll which follows:

| *Montreal Branch Active List* | *Number* | *Increase or Decrease over 1935* |
|---|---|---|
| Honorary Members | 1 | 0 |
| Members | 216 | − 5 |
| Associate Members | 498 | +12 |
| Juniors | 66 | −15 |
| Students | 258 | +52 |
| Affiliates | 15 | − 1 |
| | 1,054 | +43 |
| *Montreal Branch District Active List* | | |
| Members | 4 | −4 |
| Associate Members | 34 | +1 |
| Juniors | 7 | −4 |
| Students | 8 | −5 |
| | 53 | −12 |
| *Non-Active List* | | |
| Members | 3 | −2 |
| Associate Members | 48 | −6 |
| Juniors | 14 | −3 |
| Students | 8 | 0 |
| Affiliates | 1 | 0 |
| | 74 | −11 |

*Summary*

| | |
|---|---|
| Total Active Members | 1,107 |
| Total Non-Aetive | 74 |
| Total Membership | 1,181 |

Increase over 1935 = 20

### Members Deceased

The Committee deeply regrets to record the loss by death of the following members:

*Members:*

George Douglas MacKinnon
Robert Alexander Ross (Past President E.I.C.)
Frederick Thomson
Abbott True
F. Stuart Williamson.
Max Zuercher

*Associate Members:*

Aurelien Boyer
Jos. Labelle.
George Reakes
Frank Clinton White

*Junior:*

J. A. E. Larrivee.

### Applications

The Committee on applications dealt with a total of 43 applications for membership of which the following is a summary:

| | |
|---|---|
| Applications for admission: | |
| Member | 1 |
| Associate Members | 7 |
| Juniors | 4 |
| Branch Affiliates | 1 |
| Institute Affiliates | 1 |
| Total | 14 |
| Transfers: | |
| To Member | Nil |
| To Associate Member | 25 |
| To Junior | 4 |
| Total | 29 |

In addition to the above there were 85 Students admitted to The Institute but their applications do not pass through the Executive Committee.

### Town Planning

During the earlier part of the year there was considerable discussion regarding the necessity for improving the traffic conditions leading into Montreal, from the ends of the Island. Your executive felt that there was real need for this improvement, and accordingly passed a resolution which was sent to the Federal Government, Provincial Government, City of Montreal and various civic associations recommending that means be taken to alleviate the present congested traffic conditions.

Care had to be taken in drawing up this resolution, so as not to become involved in the political aspect of the situation, and for this reason, we refrained from mentioning any particular route.

### Reception and Entertainment Committee

This committee has sponsored all the entertainment undertaken by the Branch.

On February 11tb, an impromptu luncheon was given for the newly elected President of The Institute, E. A. Cleveland, M.E.I.C. Colonel H. F. G. Letson, M.E.I.C., President of the Association of Professional Engineers of British Columbia, and E. A. Wheatley, M.E.I.C., Registrar and Secretary Treasurer of the Association of Professional Engineers of British Columbia, were also present. As it was only known the day before of the intended visit, it was impossible to issue a general luncheon notice; however, sixty members were in attendance.

An interesting series of movie films were provided for the Branch Annual Meeting on January 9th.

To wind up the spring session a smoker was held at the Windsor Hall on April 24th. The occasion was greatly enjoyed by the three hundred or more guests and members present.

To open the fall session your committee had arranged for an evening's entertainment on one of the C.P.R. boats. Unfortunately, at the last minute the C.P.R. found it necessary to cancel these arrangements.

In view of the request for a smoking concert at the Annual Meeting of The Institute on January 29th, plans for another social event for this fall were abandoned.

The committee have always had members present at meetings of the branch for the purpose of welcoming and introducing new members, etc. They have also greatly helped the Secretary in regard to the complimentary dinners to out of town speakers.

### Papers and Meetings Committee

The report of the Chairman of the Papers and Meetings Committee is as follows:—

"The personnel of the Committee was appointed by the Executive Committees. The list of these members is given below. In addition to these members the Mechanical and Electrical Sections had the co-operation of several other Branch members who did not participate in the Committee meetings except R. C. Flitton, A.M.E.I.C., who rendered considerable assistance and attended several meetings.

"The programme of meetings for the fall and spring sessions was submitted to the Executive Committee and approved by them; these schedules are also listed below.

"Other arrangements of a general character which involved this Committee such as courtesy dinners for out-of-town speakers, invitations to sister societies to attend our meetings, etc., have been carried out as in the past.

"Early in the year it was recommended by the members of the Junior Section that it seemed inadvisable to continue the past practice of devoting two Thursday evenings in the year to Junior Nights. This recommendation was submitted to the Executive and approved. Since this time the members of the Junior Section took little part in the proceedings of the Committee and it is probable that this section need not be formally represented on the Papers Committee.

"Your Committee spent considerable time in trying to determine the proper method of approach to a programme of meetings such as ours and were strongly of the opinion that our general scheme of papers and meetings is far from ideal and is probably basically wrong. This discussion was carried on primarily to arrange our own work and a recommendation was presented to the Executive Committee early in the year. The most obvious evidence pertaining to this question is the formation of so many branch technical societies in the City all of wbicb overlap on the functions presumably taken care of in the E.I.C. If the E.I.C. cannot provide all of the technical information and the associations desired by every member or prospective member, then strenuous efforts should be made to arrange for close co-operation for mutual benefit. The alternative will tend to disintegration to some extent. In any event a close study of the whole subject would at least give the Branch valuable information as to our own condition of health.

"Further to this discussion it was the opinion of the majority of your Committee that the continuance of 'Special Technical Meetings' was not particularly desirable. In this sense, what is a technical paper? What part should any non-technical paper play in our programme? (except, of course, in a few instances). The attendance at our meetings is the accepted criterion of the success of the paper and the tendency has been that authors have through instructions or inference been somewhat general in the treatment of their papers in order to be attractive to as many of our miscellaneous membership as possible. As a result many members who should be most interested in a subject are not enthusiastic because the paper is general where it should be specific and technical, and those who could benefit most by contact with the speaker, who is presumably an expert in his subject, do not have the proper opportunity to make use of his visit or of his paper. The above applies especially to out-of-town speakers.

"It is also the opinion of several of your Committee members, although not a recommendation of the Committee as a whole, that the sections should be made much larger and should carry on as separate units, and probably to arrange for many more meetings than one per week. While the recommendation of a Sectional Committee is usually acceded to, nevertheless the Committee as a whole makes the final choice and inherently is therefore influenced by the general appeal of the subject to our miscellaneous membership. The Committee, as at present constituted, has the right to increase its numbers but it is extremely doubtful if this can be effective unless the arrangement is definitely established by the Executive.

"Your Committee is of the opinion that the present method of arranging for publication of papers and articles is not satisfactory. This matter is not a function of either the Papers Committee or of the Montreal Branch and yet both are involved in the existing set up. The Papers Committee is constantly reminded (and rightly so) to keep the requirements of the Journal in mind. On the other hand there is no consideration given to the arrangements that the Papers Committee must make, and the individuals who conclude all arrangements with the authors can make no statement whatever regarding the publication of a paper, which by the general ethics, if not by law, becomes the exclusive property of The Institute; this member cannot even say that his opinion or the opinion of the Committee will be sought or considered. The feature that your Committee feels to be unattractive is the hesitant and negative position of this contacting member in discussing with the author this matter of publication which must come up in practically all cases; not primarily because the author desires publicity but because it involves the way in which he will prepare his paper. There are other features that must be kept in mind. The Journal is the only technical publication of The Institute. Many papers are not suitable for publication, but there are many subjects that should be made available for publication that are not suitable for presentation as papers because they are narrowly technical or because they are too short to occupy a full meeting. Similar American Societies have many subjects that are published without having been presented at a meeting. There is no thought on the part of the Committee that future Committee Members should be given the right to commit The Institute to publish any article or to determine in any way the commercial procedure of the Journal which is probably the best technical magazine in Canada. But in so far as this same magazine is the only technical publication of a technical society, they recommend that consideration be given to some procedure for the guidance of those arranging for papers that will be somewhat similar to the procedure in similar societies. In connection with this matter of publication in either magazine or transactions it may be pointed out that the idea of making a paper general or popular as discussed previously renders it unattractive for publication.

"Your Committee recommends also that some definite system of continuity in the Committee membership be established that will enable the Committee in one year to conclude arrangements for papers which may have to be given in the succeeding year. They have found in three or four cases that particularly attractive papers have not been available because of the element of time; in some cases re-opening the subject in the future will not necessarily improve the point. There is at present a tacit arrangement by which a part of the Committee representation does continue, but because it is only tacit it increases rather than diminishes the reticence of one group in making commitments which will involve the freedom of choice of their successors. If half of each Committee were definitely appointed for two years there would be no such embarrassment. It is felt that the approach to an author is more representative of the desires and prestige of the E.I.C. when it is carried to a definite conclusion even if there is to be some considerable delay in the actual presentation.

"The above suggestions are made in the hope that they are constructive and it is realized that they involve functions which are not entirely the allotted work of the Papers and Meetings Committee.

"Your Committee is appreciative of the assistance given them by several members and particularly that of our Branch Secretary. With the exception of one section, the members appointed to the Committee carried out their duties sincerely and whole-heartedly and attended the many Committee meetings very faithfully."

1936 PROGRAMME OF MEETINGS

Oct. 8.—**Air Conditioning**, D. W. McLenegan.
Oct. 15.—**The Induction Motor of To-day**, E. W. Henderson.
Oct. 22.—**The 200-inch Diameter Telescope Disc**, Dr. A. O. Gage.
Oct. 29.—**Diesel Locomotives**, R. Tom Sawyer.
Nov. 5.—**Depreciation of Industrial Plants in Valuation Studies**, Herbert H. Cantwell, A.M.E.I.C.
Nov. 12.—**Fan Design and Calibration**, H. F. Hagen.
Nov. 19.—**Acoustic Networks in Radio Receivers**, Hugh S. Knowles.
Nov. 26.—**Observations of European Railroad Motive Power**, A. I. Lipetz.
Dec. 3.—**Recent Advances in Electric Welding**, H. Thomasson.
Dec. 10.—**Town Planning in Montreal**, H. A. Terreault.

1937

Jan. 14.—**Petroleum Products and the Automobile**, R. S. Weir, A.M.E.I.C.
**Gasoline for To-day's Automobile**, Gordon Connor.
Jan. 21.—**Modern Trends in Illumination**, A. L. Powell.
Jan. 29.—, Jan. 30.— Annual General Meeting.
Feb. 4.—**Recent Developments in Steam Heating**, H. F. Marshal.
Feb. 11.—**Some Phase of Radio Research**, W. Wilson.
Feb. 18.—**Modern Highway Construction**, Hon. F. J. Leduc.
Feb. 25.—**Non Ferrous Alloys**, H. J. Roast, M.E.I.C.
Mar. 4.—**Schorer Method of Analysis applied to Pipe Line Design**, A. W. F. McQueen, A.M.E.I.C., and E. M. C. Molke, A.M.E.I.C.
Mar. 11.—**Telemetering**, Perry Borden.
Mar. 18.—**Flash Butt Welding of Rails**, H. G. Drake.
Mar. 25.—**Construction of the Bridge at St. Anne de la Parade**, P. G. A. Brault, A.M.E.I.C.
April 1.—**Negative Regeneration in Communication Circuits**, C. B. Fisher, S.E.I.C.
April 8.—**Ocean Soundings by Sound Wave Reflection**, Dr. L. V. King.
April 15.—**Ship Design**, H. H. German.
April 22.—**Indeterminate Roof Trusses**, E. R. Jacobsen, S.E.I.C.
April 29.—**The Problem of Economic Stability** (As seen by an Engineer), P. A. Akerman.

PAPERS AND MEETINGS COMMITTEE

*Chairman* Brian R. Perry, M.E.I.C.
*Vice-Chairman* K. O. Whyte, A.M.E.I.C.

| | | |
|---|---|---|
| Mechanical Section.... | Kenneth G. Cameron, A.M.E.I.C. | *Chairman* |
| | R. A. Gurnham, A.M.E.I.C. | *Vice-Chairman.* |
| Electrical Section...... | D. A. Ross, A.M.E.I.C. | *Chairman* |
| | I. S. Patterson, Jr.E.I.C. | *Vice-Chairman.* |
| Civil Section.......... | Allen Bone, A.M.E.I.C. | *Chairman* |
| | R. E. Heartz, M.E.I.C. | *Vice-Chairman.* |
| Railway Section....... | G. G. Ommanney, M.E.I.C. | *Chairman* |
| | W. F. Drysdale, M.E.I.C. | *Vice-Chairman.* |
| Junior Section......... | L. A. Duchastel, Jr.E.I.C. | *Chairman* |
| | C. E. Frost, A.M.E.I.C. | *Vice-Chairman.* |
| Municipal Section..... | P. G. Delgado, A.M.E.I.C. | *Chairman* |
| | Eugene Roy, A.M.E.I.C. | *Vice-Chairman.* |
| Radio Section......... | S. T. Fisher, Jr.E.I.C. | *Chairman* |
| | D. J. McDonald, Jr.E.I.C. | *Vice-Chairman.* |

JUNIOR SECTION

*Special Committee*

Following a discussion on the "Engineer's Place in Industry" a Special Committee was formed under the Chairmanship of Mr. E. R. Smallhorn to investigate new fields of work. The object being to further the employment of engineers in industrial plants.

*University Students*

This year a special effort has been put forward in an endeavour to interest the students of L'Ecole Polytechnique to join The Institute. The Chairman, Léon A. Duchastel, Jr.E.I.C., addressed the students and pointed out the advantages to be derived by attending the meetings and becoming a Student Member. Considerable encouragement was given by the Dean, Dr. A. Mailhiot, M.E.I.C., in his introductory remarks.

At McGill a steady effort is being made to induce the students to join.

The following figures show the Student Members from Montreal admitted to The Institute.

| *Year* | *1934* | *1935* | *1936* |
|---|---|---|---|
| Ecole Polytechnique.......... | 11 | 10 | 43 |
| McGill University............ | 28 | 41 | 42 |
| Totals.............. | 39 | 51 | 85 |

*Papers and Meetings*

During the past year twelve regular meetings were held, at which fifteen papers either in French or English were read. The average attendance at the meetings was forty-nine, which is an increase over last year of eleven percent.

The papers are usually well delivered, interesting, of a high standard and bring out considerable discussion. It is felt that this section is filling a long needed want for the young engineer.

A list of the meetings and papers follows:

1936

Jan. 20.—Annual Meeting. Talk by J. B. D'Aeth, M.E.I.C., Chairman Montreal Branch.

Feb. 6.—Junior Section Night, Montreal.
**La Détermination des Cœfficients de Débit des Barrages Déversoirs à L'Aide de Modèles Réduits** by Raymond Boucher, Jr.E.I.C.
**Economical Quantity Inventory Control** by R. F. Brosseau.

Feb. 17.—**Various Types of Anti-Friction Bearings** by H. Little, S.E.I.C.
**Petroleum Products with Particular Reference to their Use in Modern Automobiles** by R. S. Weir, A.M.E.I.C.

Mar. 2.—Discussion on the recent trend towards employing engineers in connection with plant operation, supervision and maintenance and the possibility of increasing the demand for this type of engineering service. Leaders of the discussion were: R. J. Durley, M.E.I.C., on "Experience of The Institute and Employment Service," Dean Ernest Brown, M.E.I.C., on "The University Viewpoint," J. B. D'Aeth, M.E.I.C., on "Viewpoint of Engineers Generally," and Mr. T. Moran, on "Comments on Actual Experience in Employment of Engineers in a Manufacturing Plant," followed by a general discussion.

Mar. 23.—**Shop Procedure with Relation to Distortion Control** by Gordon Cape.

April 6.—**Home Air Conditioning** by Leo Roy, S.E.I.C.

April 20.—**The So-Called Problem of Public Speaking** by J. Alex Edmison.

Fall Session

Oct. 21.—Opening Meeting. Remarks by the Chairman, L. A. Duchastel, Jr.E.I.C., and E. R. Smallhorn, A.M.E.I.C.
**Incorporating your Business** by W. H. Laidley, B.C.L.

Nov. 2.—**The Interdependence of Architecture and Engineering** by Sidney S. Bunting, B. Arch., M.R.A.I.C.

Nov. 16.—**Le Haut-Fourneau Electrique** by C. Herbert, S.E.I.C.
**Development of Radio Communication in the Bush** by Mr. D. R. Taylor.

Nov. 30.—**Patents—their Value and How they are Obtained,** by Alan Swabey.
**Design and Manufacture of Aircraft** by V. S. Upton, S.E.I.C.

Dec. 14.—**Steel Rails** by Hugh J. Gordon, S.E.I.C.
**The Manufacture of Insulators** by V. F. Crowley.
Moving pictures on **Long Distance Communications** kindly supplied by the Bell Telephone Co. of Canada.

### Unemployment

With the advent of better times it was felt that there was no longer any need to call for further contributions and that the most pressing cases had been taken care of.

From the balance of $98.44 left over from last year we continued to distribute to those in most urgent need. There is a balance remaining of $12.87 which the Executive Committee decided had best be placed to the credit of the General Branch Account.

### Publicity

The Committee on Publicity has succeeded quite satisfactorily in maintaining the interest of the public through the press. The press have consistently given us advance notice of meetings and in the majority of cases given a good condensed account of the papers presented.

### Sister Societies

Among other things we have had to consider during the year is the formation of other technical society branches in Montreal and their effect on The Institute.

Perhaps as an outstanding example of these the "Montreal Branch of the Institution of Radio Engineers" might be mentioned.

This body has been recently formed and a committee of your Executive has met with some of their officers both here and in New York. The purpose of these meetings was to offer our co-operation and see if these two bodies could not be brought closer together.

As an immediate result of these conferences joint technical meetings will probably be held and it is hoped that the two bodies will eventually work closely together.

Similar conditions exist with regard to other bodies.

### Financial Statement

*Revenue*

| Ordinary: | 1935 | | 1936 | |
|---|---|---|---|---|
| Rebates from Headquarters | $1,570.20 | | $1,499.00 | |
| Rebates due from Headquarters | ..... | | 120.90 | |
| Affiliate dues | 55.00 | | 56.03 | |
| Interest | 13.03 | | 9.16 | |
| | 1,638.23 | | 1,685.09 | |
| Surplus from previous year | 1,138.00 | | 1,140.11 | |
| Extraordinary revenue | 480.66 | | 324.87 | |
| Dinners to Speakers | 154.25 | | 164.00 | |
| | | $3,411.14 | | $3,314.07 |

*Disbursements*

| | 1935 | | 1936 | |
|---|---|---|---|---|
| Postcard notices | $ 826.72 | | $ 696.02 | |
| Stationery and stamps | 24.02 | | 22.38 | |
| Secretary's honorarium | 300.00 | | 300.00 | |
| Stenographic service | 120.00 | | 120.00 | |
| Telephone and Telegraph | 60.00 | | 62 10 | |
| Lantern operator and slides | 81.00 | | 83.75 | |
| Subscriptions to Journal | 18.00 | | 16.00 | |
| Thursday refreshments | 40.78 | | 70.25 | |
| Speakers' travelling expenses | 129.38 | | 27.50 | |
| Speakers' dinners | 183.46 | | 174.59 | |
| Smokers | 447.75 | | 298.24 | |
| Miscellaneous | 39.92 | | 94.03 | |
| | 2,271.03 | | 1,964.86 | |
| Balance | 1,140.11 | | 1,349.21 | |
| | | $3,411.14 | | $3,314.07 |

### Executive Committee Meetings

During the past year the executive committee have held 10 meetings with an average attendance of 12 members per meeting.

Your secretary, after twelve years of service, finds that due to pressure of business he is unable to carry on, and has asked to be relieved of his duties.

In presenting this report your committee desires to acknowledge the assistance from members during the year, and trusts that the activities undertaken by your executive have been such as to meet with your approval.

Respectfully submitted,

J. B. D'Aeth, M.E.I.C., *Chairman.*
C. K. McLeod, A.M.E.I.C., *Secretary-Treasurer.*

## Niagara Peninsula Branch

The President and Council:—

The Executive committee of the Niagara Peninsula Branch presents herein the report for the year 1936.

The Executive held 5 regular meetings and one electoral meeting with an average attendance of eleven.

The Branch meetings are listed as follows:—

1936

Jan. 15.—Dinner meeting, Hotel Leonard, St. Catharines. Mr. J. W. Bishop, Canadian General Electric Co., on **Air Conditioning.**

Feb. 3.—Special meeting held at Council Chambers, Thorold, to discuss the report of the Committee on Consolidation and appoint delegates to the Annual Meeting.

Feb. 24.—Dinner meeting, King Edward hotel, Niagara Falls. Dr. T. Kennard Thomson, New York City, on **Some Problems of a Consulting Engineer.**

Mar. 25.—Meeting scheduled cancelled on account of weather conditions.

April 15.—Dinner meeting, Welland House, St. Catharines. Mr. C. A. Cline, Hamilton, Ont., on **Proposed Establishment of a "Free Port Area" within the Niagara Peninsula.**

May 7.—Annual Meeting, Hotel General Brock, Niagara Falls. Professor T. R. Loudon, M.E.I.C., University of Toronto, on **Aircraft Development in Europe.**

Sept. 11.—Inspection trip to the Guarantee Dye and Silk Co. plant, St. Catharines, followed by a dinner meeting at the Welland House. Mr. G. R. Wyer, Canadian Fairbanks Morse, gave a talk on **Recent Developments in Diesel Engines.**

Oct. 14.—Dinner meeting, Foxhead Inn, Niagara Falls. Mr. G. C. Grubb, Canadian Industries Ltd., Montreal, on **Uses of Explosives.**

Nov. 18.—Dinner meeting, Hotel Leonard, St. Catharines. R. A. Crysler, A.M.E.I.C., Canada Cement Co., on **Development of Cement and Concrete.**

Dec. 16.—Dinner meeting, Foxhead Inn, Niagara Falls. Mr. J. W. Bateman, Canadian General Electric Co., on **A New Viewpoint in Lighting.** Members of the A.I.E.E. joined in this meeting.

### Membership

| | |
|---|---|
| Members | 18 |
| Associate Members | 60 |
| Juniors | 6 |
| Students | 12 |
| Affiliates | 9 |
| Non-Active | 10 |
| | 115 |

FINANCIAL STATEMENT

*Receipts*

| | | |
|---|---|---|
| Bank balance, January 1st, 1936 | $300.68 | |
| Rebates | 166.65 | |
| Affiliate dues | 36.00 | |
| Meetings | 11.80 | |
| Bank interest | 2.10 | |
| | | $517.23 |

*Expenditures*

| | | |
|---|---|---|
| Meetings | $ 10.40 | |
| Printing and postage | 62.43 | |
| Exchange on checks | .30 | |
| Annual Meeting expense | 13.00 | |
| Secretary, honorarium | 100.00 | |
| Affiliate dues | 22.00 | |
| Bank balance, December 31st, 1936 | 309.10 | |
| | | $517.23 |

Respectfully submitted,
P. A. DEWEY, A.M.E.I.C., *Secretary-Treasurer.*

## Ottawa Branch

The President and Council:—

On behalf of the Managing committee of the Ottawa Branch we beg to submit the following report for the calendar year 1936.

During the year the Managing committee held eleven meetings for the transaction of general business. In addition the Branch held eighteen meetings. These meetings were well attended and excellent addresses were enjoyed at the Branch meetings.

It is with deep regret that we report the loss through death of one of our members—Mr. W. T. Cuffe-Quinn, Branch Affiliate.

As in previous years the Branch donated two sets of draughting instruments to the Ottawa Technical School for presentation as prizes for proficiency in draughting. A copy of "Standard Handbook for Electrical Engineers" was presented to the Hull Technical School to be awarded to one of its students.

PROCEEDINGS AND PUBLICITY

During the year eighteen luncheon meetings were held. The dates of the meetings and speakers are as follows:—

1936

Jan. 23.—Dr. T. E. Warren, **The Hydrogenation of Coal.** Attendance 81.

Feb. 13.—Dr. C. D. Niven, **The Insulation of Houses and Allied Problems.** Attendance 129.

Feb. 27.—Dr. D. de Waal Meyer, **Communications in South Africa.** Attendance 88.

Mar. 12.—Dr. E. S. Archibald, **Soil Drifting.** Attendance 87.

Mar. 26.—Norman Jaques, M.P., **Social Credit as it relates to the Engineering Profession.** Attendance 81.

April 2.—F. W. Bridges, **Fifty Years of Ship-building—A Retrospect.** Attendance 82.

April 16.—Sir Francis Floud, **Housing in Great Britain.** Attendance 108.

April 30.—Lt.-Col. E. L. M. Burns, **New Air Survey Methods.** Attendance 112.

May 14.—R. F. Leggett, A.M.E.I.C., **Steel Piling.** Attendance 58.

May 28.—R. C. Manning, **Steel Construction.** Attendance 99.

Aug. 20.—B. J. Meighan, **Civil Engineering and Contracting in Great Britain.** Attendance 74.

Sept. 4.—Dr. F. C. Breckenridge, **Trends in Aviation Lighting.** Attendance 70.

Sept. 16.—Dr. E. A. Cleveland, M.E.I.C., President of The Engineering Institute of Canada, **Institute Affairs.** Attendance 76.

Oct. 22.—Dr. G. C. Laurence, **Radium, its Production and Use.** Attendance 80.

Nov. 5.—J. F. Harkom, A.M.E.I.C., **Preservative Treatment of Structural Timbers.** Attendance 65.

Nov. 19.—M. F. Goudge, **The Construction of the Vimy Memorial.** Attendance 95.

Dec. 3.—F. D. Laurie, **Changing Over to the Dial System.** Attendance 106.

Dec. 17.—Dr. J. M. Swaine, **The Greatest Menace to Canadian Forests.** Attendance 70.

MEMBERSHIP

With several adjustments during the year the membership roll now shows a decrease of 5 during the year.

The following table shows in detail the comparative figures for the years 1935 and 1936:—

| | *1935* | *1936* |
|---|---|---|
| Honorary Members | 1 | 2 |
| Members | 83 | 82 |
| Associate Members | 170 | 170 |
| Affiliates of Institute | 3 | 3 |
| Juniors | 14 | 17 |
| Students | 32 | 30 |
| Branch Affiliates | 31 | 28 |
| Resident Members | 334 | 332 |
| District Members | 74 | 70 |
| Total | 408 | 402 |

FINANCES

The attached financial statements show that the Branch had an excess of $27.40 in expenditures over revenue at the end of the year. The year closed with a balance of $648.94 in the bank, $10.13 cash on hand, and $1,000 in Government Bonds. In addition the Branch had assets of $26.60 in rebates due from the Main Institute, $33.15 due from the Proceedings committee, and $21.00 in equipment, etc.

AERONAUTICAL SECTION

Seven evening meetings were held, when technical papers dealing with aeronautical or related subjects were read and discussions held. The average attendance was 28, an increase of 10 over the previous year.

OFFICERS FOR 1937

The annual meeting of the Branch will be held on the 14th of January when the officers and members of the Managing committee for 1937 will be elected.

FINANCIAL STATEMENT

*Receipts*

| | | | |
|---|---|---|---|
| Interest on Dominion of Canada Bonds | | $ 42.50 | |
| Bank interest | | 4.32 | |
| Rebates from Main Institute:— | | | |
| November and December, 1935 | $ 43.90 | | |
| January to April, 1936 | 407.40 | | |
| May to September, 1936 | 61.20 | | |
| | | 512.50 | |
| Branch Affiliate fees | | 77.00 | |
| Proceeds sale of luncheon tickets | | 745.00 | |
| Refund from dinner dance | | 91.95 | |
| | | $1,473.27 | |
| Balance in bank, December 31st, 1935 | | 666.90 | |
| Cash on hand, December 31st, 1935 | | 19.57 | |
| | | | $2,159.74 |

*Expenditures*

| | | |
|---|---|---|
| Luncheons | $1,171.95 | |
| Catering | 25.00 | |
| Grant to Aeronautical Section | 20.00 | |
| Printing | 214.04 | |
| Subscriptions to Engineering Institute Journal | 6.00 | |
| Sundries, gratuities, prizes, etc. | 53.00 | |
| Petty cash, postage, telegrams, etc. | 10.68 | |
| | $1,500.67 | |
| Cash on hand, December 31st, 1936 | 10.13 | |
| Balance in bank, December 31st, 1936 | 648.94 | |
| | | $2,159.74 |

*Assets*

| | | |
|---|---|---|
| Stationery and equipment | $ 20.00 | |
| Library | 1.00 | |
| Rebates due from Main Institute account fees, 1936 | 26.60 | |
| Dominion Government Bonds | 1,000.00 | |
| Due from sale of luncheon tickets | 33.15 | |
| Balance in bank | 648.94 | |
| Cash on hand | 10.13 | |
| | | $1,739.82 |

*Liabilities*

| | |
|---|---|
| Surplus | $1,739.82 |

Respectfully submitted,
E. VIENS, M.E.I.C., *Chairman.*
F. C. C. LYNCH, A.M.E.I.C., *Secretary-Treasurer.*

### Aeronautical Section

OFFICERS

The officers for the year were:—

*Chairman.*—Dr. J. J. Green
Wind Tunnel,
National Research Council,
Ottawa, Ontario.

*Secretary*—J. T. Dyment, S.E.I.C.,
Assistant Engineer,
Aeronautical Engineering Division,
Department of National Defence,
Ottawa, Ontario.

PROCEEDINGS

The following technical papers were given at evening meetings of the Aeronautical Section:—

1936

Jan. 24.—Mr. E. J. Mulligan, Chief Test Engineer of Canadian Wright Ltd. Subject: **The Cyclone Engine and Test Visit.** Attendance 10.

Feb. 4.—Mr. R. J. Moffet, Manager of the Aircraft Department of Canadian Vickers. Subject: **Metal Aircraft Construction as Exemplified by Northrop.** Attendance 15.

Feb. 20.—Group Captain E. W. Stedman, O.B.E., F.R.Ae.S., M.E.I.C., etc., Chief Aeronautical Engineer for the Department

of National Defence. Subject: **Stratosphere Flying.** Attendance 40.
Mar. 12.—Capt. M. Windsor, Canadian representative of the Armstrong Siddeley Motors of England. Subject: **Tour of Aeroplane and Engine Shops.** Attendance 50.
Mar. 19.—Mr. K. F. Tupper, B.A.Sc., A.F.R.Ae.S., etc., of the National Research Council. Subject: **Fatigue of Metals.** Attendance 15.
April 16.—Mr. E. M. Lester, B.S., M.S., Assistant Executive Engineer for Pratt and Whitney Aircraft Corp. Subject: **Controllable Pitch Propellers.** Attendance 32.
April 30.—Mr. R. J. Anderson, B.A.Sc., District Service Engineer for the Dominion Oxygen Company. Subject: **Welding of Light Walled Tubing.** Attendance 34.

The average attendance was 28, an increase of 10 over the previous year.

Almost all the consistent attendants were members of The Engineering Institute of Canada or the Royal Aeronautical Society. No charge was levied on casual visitors as they usually came by invitation of the Secretary.

FINANCIAL STATEMENT

*Receipts*

| | | |
|---|---|---|
| Cash carried over from 1935 | $0.85 | |
| Bank balance carried over from 1935 | 9.10 | |
| Fees | 10.00 | |
| Grant from Ottawa Branch | 20.00 | |
| | | $39.95 |

*Expenditures*

| | | |
|---|---|---|
| Cash on hand, December 31st, 1936 | $3.70 | |
| Cash in bank, December 31st, 1936 | .73 | |
| Postcards | 32.52 | |
| Mimeograph | 1.65 | |
| Postage stamps | 1.35 | |
| | | $39.95 |

## Peterborough Branch

The President and Council:—

I have the honour to submit on behalf of the Executive committee, Peterborough Branch, Engineering Institute of Canada, the following report covering the activities of the Branch during the year 1936:—

MEETINGS

1936
Jan. 9.—**Mechanized Warfare** by Lt.-Col. N. C. Sherman, M.E.I.C., Military District No. 3, Kingston, Ont. Attendance 67.
Feb. 20.—**Nickel Alloys** by Mr. Hugh G. Watson, foundry engineer, Peckovers Ltd., Toronto, Ont. Attendance 26.
Mar. 12.—**The Mining Industry** by Mr. G. C. Monture, editor in chief of publication "Mines Branch," Ottawa. Attendance 29.
April 15.—Annual Students and Junior Night. **The Engineer in Social Life** by A. R. Jones, Jr.E.I.C.; **Metal Radio Tubes** by Mr. G. Levy; **Panic** by R. S. Hull, Jr.E.I.C.; **A Mathematical Problem** by A. J. Girdwood, Jr.E.I.C.; **The Modern Pipe Organ** by Mr. W. S. McMullen. Attendance 34.
May 7.—Annual Meeting, reports and election of officers. Attendance 31.
Sept. 19.—Annual Outing to R.C.A.F. Station, Trenton, Ont. Attendance 50.
Oct. 8.—**Metalizing and Metal Spraying** by Mr. C. E. Simpson, consulting engineer, Toronto. Attendance 30.
Nov. 17.—Annual Dinner. Mr. Desmond Killikelly, Assistant to the Vice-President, Steel Company of Canada. Subject, **Canada in the Midst of the World's Political Unrest.** Attendance 63.
Dec. 10.—**Concrete Highways** by D. O. Robinson, A.M.E.I.C., publicity engineer, Canada Cement Company, Toronto. Attendance 25.

Number of Executive meetings held during the year was seven. Special sub-committees were as follows:

| | |
|---|---|
| Meetings and Papers Committee | V. R. Currie, A.M.E.I.C. |
| | E. J. Davies, A.M.E.I.C. |
| | B. Ottewell, A.M.E.I.C. |
| Branch News Editor | E. J. Davies, A.M.E.I.C. |
| Membership and Attendance Committee | A. L. Dickieson, A.M.E.I.C. |
| | D. J. Emery, Jr.E.I.C. |
| | A. L. Killaly, A.M.E.I.C. |
| Social and Entertainment Committee | W. M. Cruthers, A.M.E.I.C. |
| | A. L. Killaly, A.M.E.I.C. |
| | A. B. Gates, A.M.E.I.C. |
| By-laws and Development | A. B. Gates, A.M.E.I.C. |
| | R. L. Dobbin, M.E.I.C. |
| Auditor | E. R. Shirley, M.E.I.C. |

MEMBERSHIP

| | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 |
|---|---|---|---|---|---|---|---|---|
| Members | 20 | 18 | 15 | 13 | 13 | 11 | 11 | 11 |
| Associate Members | 31 | 30 | 34 | 36 | 35 | 30 | 32 | 39 |
| Juniors | 20 | 20 | 19 | 13 | 11 | 12 | 11 | 9 |
| Students | 30 | 23 | 19 | 16 | 16 | 18 | 25 | 23 |
| Branch Affiliates | 25 | 17 | 15 | 17 | 14 | 13 | 9 | 9 |
| | 126 | 108 | 102 | 95 | 89 | 84 | 88 | 91 |
| Institute Affiliates | | | | | | | | 2 |
| Honorary Branch Affiliates | | | | | | | | 1 |
| | | | | | | | | 94 |

FINANCIAL STATEMENT

*Receipts*

| | | |
|---|---|---|
| Balance, December 31st, 1935 | $100.43 | |
| Affiliate fees | 34.00 | |
| Rebate from Headquarters | 114.90 | |
| Annual dinner | 87.00 | |
| Donation | 2.00 | |
| Bank interest | .72 | |
| | $339.05 | |
| Rebate from Headquarters | 6.30 | |
| | | $345.35 |

*Expenses*

| | | |
|---|---|---|
| Affiliate fees to Headquarters | $ 16.30 | |
| Rent | 24.00 | |
| Announcement cards | 37.04 | |
| Stamps | 6.00 | |
| Envelopes, telegrams, etc | 2.00 | |
| Annual banquet | 122.10 | |
| Flowers | 7.00 | |
| Lantern insurance | 4.80 | |
| Speakers' expenses | 16.10 | |
| Students' badges | 7.50 | |
| Balance, December 31st, 1936 | 96.21 | |
| | $339.05 | |
| Rebate from Headquarters | 6.30 | |
| | | $345.35 |

Employment conditions of engineers in our district are practically on a level with those of pre-depression years.

Respectfully submitted,
W. T. FANJOY, A.M.E.I.C., *Secretary-Treasurer.*

## Quebec Branch

The President and Council:—

On behalf of the Executive committee of the Quebec Branch, we beg to submit the annual report for the calendar year 1936:—

MEMBERSHIP

| | *Resident* | *Non-Resident* | *Total* |
|---|---|---|---|
| Branch Honorary Member | 1 | 0 | 1 |
| Members | 19 | 0 | 19 |
| Associate Members | 66 | 9 | 75 |
| Juniors | 2 | 3 | 5 |
| Students | 9 | 2 | 11 |
| Affiliates | 1 | 0 | 1 |
| | 98 | 14 | 112 |

It is with deep regret that we report the death of F. T. Cole, M.E.I.C., and D. Lemieux, S.E.I.C.; both passed away during the course of the year.

MEETINGS

Four meetings of the Branch Executive committee were held during the year and seven Branch meetings, as follows:—

1936
Jan. 11.—Luncheon meeting at Chateau Frontenac. Our guest of honour, Dr. F. A. Gaby, M.E.I.C., President of The Institute, addressed the meeting on Institute's affairs and delivered a lecture on **Transportation Problems.**
Feb. 17.—Luncheon meeting at Chateau Frontenac. Speaker, P. S. Gregory, M.E.I.C., assistant general manager, Shawinigan Water and Power Co., Montreal. Subject: **Utilization of Secondary Electric Energy for the Production of Steam.**
Mar. 30.—Evening meeting at Chateau Frontenac. Speakers and subjects: J. H. A. Laplante, S.E.I.C., (Quebec Roads Department), **Le revêtement économique des chaussées**; Maurice Archambault, C.E. (Bureau of Mines, Quebec), **Engineering and the Mining Industry of Quebec**; J. H. Theriault, C.E. (Quebec Roads Department), **Construction des pavages en béton.**

May 4.—Luncheon meeting at Chateau Frontenac. Speaker: Alfred Marois, C.E., Chairman of the Quebec Board of Trade. Subject: **Le rôle de l'ingénieur dans l'industrie.**

June 5.—Annual Meeting and election of officers at Montcalm Palace.

Sept. 17.—Luncheon meeting at Chateau Frontenac. Guest of honour, E. A. Cleveland, M.E.I.C., President of The Institute, who addressed the meeting on Institute's problems.

Dec. 7.—Evening meeting at Chateau Frontenac. Speaker: G. Lorne Wiggs, A.M.E.I.C., consulting engineer, Montreal. Subject: **Fundamentals of Air Conditioning.**

Committees

Special Branch committees are as follows:—

| | |
|---|---|
| Nominating | L. P. Methe, A.M.E.I.C. |
| | J. O. Martineau, M.E.I.C. |
| | E. D. Gray-Donald, A.M.E.I.C. |
| Legislation | L. Beaudry, A.M.E.I.C. |
| | R. Wood, A.M.E.I.C. |
| | J. O. Martineau, M.E.I.C. |
| Membership | H. Cimon, M.E.I.C. |
| | O. Desjardins, A.M.E.I.C. |
| | J. Joyal, M.E.I.C. |
| Unemployment | H. Cimon, M.E.I.C. |
| | A. G. Sabourin, A.M.E.I.C. |
| | L. Martin, A.M.E.I.C. |
| Excursion | T. M. Dechene, A.M.E.I.C. |
| | J. L. Bizier, A.M.E.I.C. |
| | M. G. Archer, S.E.I.C. |
| Library | L. P. Methe, A.M.E.I.C. |
| | J. O. Martineau, M.E.I.C. |
| | T. M. Dechene, A.M.E.I.C. |
| | R. Sauvage, A.M.E.I.C. |
| | M. G. Archer, S.E.I.C. |
| Semicentennial | H. Cimon, M.E.I.C. |
| | J. T. F. King, A.M.E.I.C. |
| | L. P. Methe, A.M.E.I.C. |
| | L. Beaudry, A.M.E.I.C. |

Financial Statement

| | | |
|---|---|---|
| *Receipts* | | |
| Bank balance, January 1st, 1936 | $ 38.54 | |
| Rebates—May, 1936 | 172.20 | |
| Rebates—October, 1936 | 26.10 | |
| Rebates—December, 1936 | 15.30 | |
| Bank interest | .27 | |
| | | $252.41 |
| *Expenditures* | | |
| Meetings | $ 42.15 | |
| Stamps, post cards, etc | 16.69 | |
| Printing | 43.86 | |
| Honorarium to Secretary | 100.00 | |
| | $202.70 | |
| Rebates—December, 1936 | 15.30 | |
| Balance in bank, December 31st, 1936 | 34.41 | |
| | | $252.41 |

Respectfully submitted,
A. Lariviere, M.E.I.C., *Chairman.*
Jules Joyal, M.E.I.C., *Secretary-Treasurer.*

## Saguenay Branch

The President and Council:—

The Executive committee of the Saguenay Branch wish to submit the following report for the calendar year 1936.

Membership

| | |
|---|---|
| Members | 3 |
| Associate Members | 30 |
| Juniors | 4 |
| Students | 10 |
| Affiliates | 1 |
| Total | 48 |

Meetings

During the year meetings were held as follows:—

1936

Aug. 22.—The Annual General Meeting and dinner was held at Kenogami. F. L. Lawton, M.E.I.C., addressed the meeting, his subject being **Cost and Performance Data on Several Forms of House Insulation in Houses Built in the Saguenay District.**

Nov. 4.—At Arvida. A paper on **Maintenance Problems Commonly Met With** was presented by M. G. Saunders, A.M.E.I.C.

Financial Statement

| | | |
|---|---|---|
| *Receipts* | | |
| Balance at December 31st, 1935 | $193.98 | |
| Rebates from Headquarters | 81.60 | |
| | $275.58 | |
| Rebates payable, December 31st, 1936 | 3.30 | |
| | | $278.88 |
| *Expenditures* | | |
| Stationery | $ 13.30 | |
| Exchange on cheques | .95 | |
| Postage | 9.32 | |
| Expense of meetings | 37.45 | |
| | $ 61.02 | |
| Balance in bank, December 31st, 1936 | 214.56 | |
| | $275.58 | |
| Rebates payable, December 31st, 1936 | 3.30 | |
| | | $278.88 |

Respectfully submitted,
S. J. Fisher, M.E.I.C., *Chairman.*
G H. Kirby, A.M.E.I.C., *Secretary-Treasurer.*

## Saint John Branch

The President and Council:—

On behalf of the Executive committee, we beg to submit the annual report for the calendar year 1936:—

Membership

| | Resident | Non-Resident | Total |
|---|---|---|---|
| Members | 10 | 6 | 16 |
| Associate Members | 18 | 15 | 33 |
| Juniors | 6 | 4 | 10 |
| Students | 17 | 27 | 44 |
| Affiliates | 1 | .. | 1 |
| | 52 | 52 | 104 |

Meetings

Ten meetings of the Branch Executive committee were held during the year and six Branch meetings as follows:—

1936

Jan. 30.—The annual joint dinner meeting with the Association of Professional Engineers of the Province of New Brunswick. T. C. Macnabb, M.E.I.C., General Superintendent of the New Brunswick Division of the C.P.R., gave an illustrated talk on **Arctic Flying.**

Feb. 20.—A dinner dance was held by the Branch in the Admiral Beatty hotel with an attendance of 159.

Mar. 5.—D. O. Turnbull, Jr.E.I.C., of the Foundation Co., read a paper, illustrated by slides, on **The Foundation Scarboro,** one of the largest floating derricks in Canada.

Mar. 26.—D. O. Robinson, A.M.E.I.C., read a paper on **Modern Cement Concrete Highways.**

May 7.—Annual dinner and meeting of the Branch at the Riverside Golf and Country Club. The present officers were elected at this meeting. Lt.-Col. P. B. Fleming of the U.S. Army Corps of Engineers addressed the meeting on **The Passamaquoddy Tidal Power Project.** The address was illustrated by slides and moving pictures.

Aug. 27., 28., 29.—A Maritime Professional meeting was held in Saint John with a total registration of 114. The technical papers read were as follows: **Stabilization, Realignment and Surfacing of New Brunswick Roads** by D. R. Smith of the New Brunswick Highway Department; **The Fundamentals of Air Conditioning** by G. L. Wiggs, A.M.E.I.C., of Montreal; and **The Reconstruction of Berths 1, 2, 3 and 4 in Saint John Harbour** by V. S. Chesnut, A.M.E.I.C.

Inspection trips included a visit to the above Berths; a boat trip around the Harbour in a tugboat supplied by the Saint John Drydock and Shipbuilding Co.; and a car trip to the Passamaquoddy Tidal Power Project.

Entertainment included a dinner dance, on the evening of the 27th; luncheon as guests of the Foundation Co. and the Saint John Drydock and Shipbuilding Co. at noon on the 28th; and luncheon as guests of the Saint John Branch at Eastport. The ladies were guests of the Saint John Branch at a luncheon at the Westfield Golf Club on the afternoon of the 28th. The Hon. Michael Dwyer, Minister of Mines in Nova Scotia addressed the Branch on the evening of the 28th.

Employment

Although there are quite a few unemployed, especially among the Students and Juniors, the employment situation shows considerable improvement at present.

Financial Statement

*Receipts*

| | | |
|---|---|---|
| Balance, December 31st, 1935 | $293.52 | |
| Headquarters rebates—January to April | 103.20 | |
| Headquarters rebates—May to September | 26.10 | |
| Headquarters rebates—October to December | 16.50 | |
| February 20th, Dinner Dance tickets | 127.75 | |
| Headquarters grant for Maritime Professional Meeting | 200.00 | |
| August 27th, Dinner Dance tickets | 247.25 | |
| | | $1,014.32 |

*Expenditures*

| | | |
|---|---|---|
| February 20th, Dinner Dance | $137.75 | |
| Stamps and post cards | 15.85 | |
| Printing | 35.28 | |
| Lantern rental | 14.00 | |
| Maritime Professional Meeting | 447.25 | |
| Branch meetings | 20.00 | |
| Stenographer | 10.00 | |
| Honorarium to Secretary | 25.00 | |
| Balance, December 31st, 1936 | 292.69 | |
| Rebates, October to December | 16.50 | |
| | | $1,014.32 |

Respectfully submitted,

J. R. Freeman, m.e.i.c., *Chairman.*
F. A. Patriquen, Jr.e.i.c., *Secretary-Treasurer.*

## St. Maurice Valley Branch

The President and Council:—

There was very little, if anything, done by this Branch during the year just ended. There was one general meeting, two meetings of the Executive committee, and one technical meeting, at which A. C. Abbott, a.m.e.i.c., distribution engineer, Shawinigan Water and Power Company, Three Rivers, was the speaker.

Financial Statement

*Receipts*

| | | |
|---|---|---|
| In bank, January 1st, 1936 | $ 83.46 | |
| Rebates from Headquarters | 70.20 | |
| | | $153.66 |

*Expenditures*

| | | |
|---|---|---|
| Stationery | $ 2.35 | |
| Stationery | 2.12 | |
| Stamps | 2.00 | |
| Floral tribute | 5.00 | |
| Balance in bank, December 31st, 1936 | 142.19 | |
| | | $153.66 |

Respectfully submitted,

J. Albert Hamel, a.m.e.i.c., *Secretary-Treasurer.*

## Saskatchewan Branch

The President and Council:—

On behalf of the Executive we submit the following report of the activities of the Saskatchewan Branch for the year 1936:—

Membership

The membership of the Branch shows an increase of five over last year, being as follows:—

| | Resident | Non-Resident | Total |
|---|---|---|---|
| Members | 20 | 10 | 30 |
| Associate Members | 17 | 24 | 41 |
| Juniors | 7 | 6 | 13 |
| Students | 3 | 12 | 15 |
| Branch Affiliates | 2 | 1 | 3 |
| | 49 | 53 | 102 |

Committees

The Executive committee was elected on March 20th, 1936 and held five meetings during the year (including trip to Fort Peck).

The standing committees are:—

Papers and Library............R. W. Allen, m.e.i.c., Convenor.
Nominating..................D. A. R. McCannel, m.e.i.c., Convenor.
Membership..................J. J. White, m.e.i.c., Convenor.

Meetings

There were four regular meetings of the Branch, each being preceded by a dinner at which the average attendance and general interest was good. In addition, a general meeting was held during the month of October under the auspices of the Association of Professional Engineers.

The trip to Fort Peck dam proved to be of great educational and instructive value, so much so that those who attended contemplate another trip in 1937.

The programme for the year was as follows:—

1936

Jan. 24.—Address by Dr. E. W. Stapleford on **Blazing New Trails.**

Mar. 20.—Address by Stewart Young, m.e.i.c., on **Reminiscences of Mountain Climbing in British Columbia,** illustrated by maps and charts.

Sept. 19.—Members of the Branch visited Fort Peck Dam, Montana, U.S.A.

Nov. 20.—Address by Professor R. A. Spencer, a.m.e.i.c., on **Some Modern Highway Tunnels and Long Span Bridges,** illustrated by lantern slides.

Dec. 18.—Address by W. H. Ross, r.p.e. Saskatchewan, on **Diesel Engines.**

Finances

The financial standing of the Branch is as follows:—

*Receipts*

| | | |
|---|---|---|
| Bank balance, December 31st, 1935 | $ 53.39 | |
| Rebate from Headquarters | 178.65 | |
| Branch dues | 8.00 | |
| Miscellaneous | 8.00 | |
| | | $248.04 |

*Expenditures*

| | | |
|---|---|---|
| Postage | $ 8.61 | |
| Meetings (notices, printing, etc.) | 66.43 | |
| Secretarial | 50.00 | |
| Miscellaneous | 26.53 | |
| Bank balance, December 31st, 1936 | 96.47 | |
| | | $248.04 |

Respectfully submitted,

W. E. Lovell, m.e.i.c., *Chairman.*
J. J. White, m.e.i.c., *Secretary-Treasurer.*

## Sault Ste. Marie Branch

The President and Council:—

On behalf of the Executive committee we submit the following report of the Sault Ste. Marie Branch for the calendar year 1936:—

The Executive committee met January 27th and appointed standing committees as follows:—

Papers and Publicity..................Wm. Seymour, m.e.i.c.
Legislation and Remuneration.........F. Smallwood, m.e.i.c.
Entertainment........................C. W. Holman, a.m.e.i.c.
Membership...........................E. M. MacQuarrie, a.m.e.i.c.

The unemployment committee which functioned during the year 1935 was discontinued, the Executive feeling that the need for this committee was over due to the betterment of business conditions in this territory.

The Executive committee met seven times during the year to discuss and promote Branch activities.

Seven dinner meetings were held during the year. No regular meeting date was adhered to rigidly as the Executive found that it was necessary to fit the date of the meeting to suit the convenience of the speakers.

Programmes of the meetings were as follows:—

1936

Jan. 3.—Annual Meeting for 1935—followed by a social evening.

Feb. 6.—**Aluminum Cables, Steel Reinforced, for Electrical Conductors** by Mr. Theodore Varney, consulting engineer, Aluminum Company of Canada.
**Some Aspects of Aluminum and its Alloys** by Mr. W. M. Gifford, Vice-President, Aluminum Company of Canada.

Mar. 6.—**Aeronautical Development and Design** by Mr. George Ponsford, Director of Province of Ontario Air Service. This meeting was followed by an interesting tour of the local aerodrome.

April 8.—**Informal Talk** by His Honour Judge Frederick Stone. A social evening followed this enjoyable address.

May 20.—**Alloy Irons** by Mr. Hugh Watson, chief engineer, Peckovers Limited.

Oct. 30.—**Human Relations and the Engineer** by R. S. McCormick, m.e.i.c., chief engineer and general superintendent, Algoma Central and Hudson Bay Railway.

Nov. 30.—**Gold** by O. A. Evans, Jr.e.i.c., Mines Department, Algoma Central & Hudson Bay Railway.

The membership record of the Branch at the close of 1936 is as follows:—

| | Resident | | Non-Resident | | Total | |
|---|---|---|---|---|---|---|
| Regular | 1935 | 1936 | 1935 | 1936 | 1935 | 1936 |
| Members | 9 | 9 | 11 | 8 | 20 | 17 |
| Associate Members | 10 | 10 | 25 | 27 | 35 | 37 |
| Juniors | 4 | 3 | 10 | 12 | 14 | 15 |
| Students | 1 | .. | 12 | 14 | 13 | 14 |
| Branch Affiliates | 8 | 9 | .. | .. | 8 | 9 |
| | 32 | 31 | 58 | 61 | 90 | 92 |
| Associate Members | 1 | 1 | 2 | 1 | .. | .. |
| Junior Members | .. | .. | 1 | 1 | .. | .. |
| Non-Active | .. | .. | .. | .. | .. | .. |

The movement of members during 1936 is summarized as follows:—

| | In | Out | Transfer |
|---|---|---|---|
| Elected to Membership | 6 | .. | .. |
| Moved out of Branch | .. | 13 | .. |
| Moved into Branch | 15 | .. | .. |
| Resignations and Non-Actives | .. | 6 | .. |
| Transfer to higher grade | .. | .. | 3 |
| | 21 | 19 | 3 |

Net gain ............ 2 Regular Members
Net loss ............ 1 Non-Active Member

FINANCIAL STATEMENT

*Revenue*

| | 1935 | 1936 |
|---|---|---|
| Rebates from Headquarters | $145.20 | $135.75 |
| Journal subscriptions | 10.00 | 10.00 |
| Affiliate fees | 24.00 | 26.00 |
| Entertainment | 44.00 | 80.50 |
| Interest on savings | 3.96 | 1.50 |
| | $227.16 | $253.75 |

*Expenditures*

| | 1935 | 1936 |
|---|---|---|
| Printing and stationery | $ 31.68 | $ 32.08 |
| Journal subscriptions to Headquarters | 10.00 | 10.00 |
| Postage and telegraph | 8.14 | 16.70 |
| Entertainment | 68.05 | 121.45 |
| Miscellaneous expenses | 3.00 | 1.75 |
| Honorarium due Secretary | 25.00 | 25.00 |
| Surplus | 81.29 | 46.77 |
| | $227.16 | $253.75 |

*Assets*

| | 1935 | 1936 | 1935 | 1936 |
|---|---|---|---|---|
| Cash—Current account | $184.23 | $221.10 | | |
| Savings account | 201.96 | 203.46 | | |
| Petty cash | 3.56 | 1.96 | | |
| Total cash | | | $389.75 | $426.52 |
| Receivables— | | | | |
| Affiliate fees owing | 12.00 | 21.00 | | |
| Journal subscriptions unpaid | 4.00 | 8.00 | | |
| Total receivables | | | 16.00 | 29.00 |
| Inventory—Stationery | 12.30 | 9.30 | 12.30 | 9.30 |
| Property | 1.00 | 1.00 | 1.00 | 1.00 |
| | $419.05 | $465.82 | $419.05 | $465.82 |

*Liabilities*

| | 1935 | 1936 | 1935 | 1936 |
|---|---|---|---|---|
| Honorarium due Secretary | $ 25.00 | $ 25.00 | $ 25.00 | $ 25.00 |
| Capital surplus | 394.05 | 440.82 | 394.05 | 440.82 |
| | $419.05 | $465.82 | $419.05 | $465.82 |

Respectfully submitted,
J. L. LANG, M.E.I.C., *Chairman.*
N. C. COWIE, Jr.E.I.C., *Secretary-Treasurer.*

## Toronto Branch

The President and Council:—

On behalf of the Executive committee we submit the annual report of the Toronto Branch for 1936.

The annual meeting of the Branch was held at the Canadian Military Institute on April 16, 1936, and was preceded by a dinner.

The chairmen of standing committees are:

Papers ............ O. Holden, A.M.E.I.C.
Finance ............ C. E. Sisson, M.E.I.C.
Publicity ............ A. U. Sanderson, A.M.E.I.C.
Meetings ............ Nicol MacNicol, M.E.I.C.
Membership ............ W. E. P. Duncan, M.E.I.C.
Student Relations ............ A. M. Reid, A.M.E.I.C.
Branch Editor ............ D. D. Whitson, A.M.E.I.C.
Social ............ W. E. Bonn, M.E.I.C.

During the past year the Executive committee has held 13 meetings for the transaction of Branch business, with an average attendance of about nine at each meeting.

The following regular meetings were held during 1936:

1936

Jan. 16.—**The Economic Value of the Steel Industry to Canada**, Mr. A. G. Wright, Dominion Foundries and Steel, Ltd., Hamilton. Attendance 75.

Jan. 29.—Two Hundredth Anniversary of the Birth of James Watt. Meeting arranged by the University with the co-operation of The Engineering Institute of Canada, the American Society of Mechanical Engineers, the Institution of Mechanical Engineers, and the American Institute of Electrical Engineers. Speakers, Brig.-General C. H. Mitchell, M.E.I.C., Professor Robt. W. Angus, M.E.I.C., and Professor E. A. Allcut, M.E.I.C. Attendance 425.

Feb. 20.—**Radium**, Mr. F. B. Friend, Eldorado Gold Mines, Ltd. Attendance 60.

Mar. 5.—**Sheet Piling**, Robt. F. Leggett, A.M.E.I.C., Canadian Sheet Piling Company. Attendance 60.

Mar. 17.—**Acoustics**, Mr. C. W. Meyer, Johns Manville Co., New York. Attendance 150.

Mar. 27.—**Fifty Years of Ship Building—A Retrospect**, Fred Bridges, M.E.I.C., Sorel, Que. Attendance 25.

April 16.—Annual Meeting. Dinner at the Canadian Institute following which Professor L. Joslyn Rogers spoke on **Technical Methods in the Detection of Crime.** Attendance 55.

Oct. 2.—**Musical Sounds and their Engineering**, Dr. W. B. White, American Steel and Wire Co., Chicago. A joint meeting with the American Society of Metals and the American Society of Mechanical Engineers. Attendance 150.

Oct. 15.—**The Geology of Northern Ontario**, Mr. H. C. Rickaby, Ontario Provincial Geologist. Attendance 80.

Nov. 5.—**Metal Mining and Milling**, C. G. Williams, B.A.Sc., consulting mining engineer. Attendance 85.

Nov. 18.—**Forestry**, Dean C. D. Howe, Faculty of Forestry, University of Toronto. Attendance 30.

Dec. 3.—**Pulp and Paper**, E. W. McBride, A.M.E.I.C., Abitibi Power and Paper Company. Attendance 70.

In addition to the regular meetings, two social evenings have been held, one in April and one in December, for members and their wives, at which about eighty were present on each occasion. These were held at the Engineers Club, where dinner was served and the evening spent with music, billiards, bridge and other entertainment.

It will again be noted that a number of meetings have been held with other engineering societies, and these have proved most successful and enjoyable. Dinner is frequently arranged before the regular Branch meetings and this affords an opportunity for the members to meet in a social way.

The Toronto Branch E.I.C. Loan Fund, established four years ago for the assistance of members, is in a satisfactory condition and during the past two years no applications for help have been received. At the present time there is a balance of $298.01 in the Fund.

The membership of the Branch, as at December 31st, 1936. is as follows:

| | Resident | Non-Resident | Non-Active | Total |
|---|---|---|---|---|
| Members | 124 | 7 | 4 | 135 |
| Associate Members | 195 | 7 | 30 | 232 |
| Juniors | 40 | 4 | 9 | 53 |
| Students | 68 | 13 | 5 | 86 |
| Affiliates | 5 | .. | .. | 5 |
| | 432 | 31 | 48 | 511 |

It is with regret that we record the death of the following members during the year: Colonel C. J. Ingles, M.E.I.C., and Thos. Taylor, M.E.I.C.

FINANCIAL STATEMENT

*Receipts*

| | | | |
|---|---|---|---|
| Bank balance, January 6th, 1936 | | $452.77 | |
| Rebates from Headquarters | $578.20 | | |
| Rebate on printing | 38.04 | | |
| Refund from Annual Meeting committee | 11.00 | | |
| Proceeds of dinner, Engineers Club | 98.75 | | |
| Interest | 10.04 | | |
| | | 736.03 | |
| | | | $1,188.80 |

*Expenditures*

| | | | |
|---|---|---|---|
| Advertisement in "Transactions" | $ 20.00 | | |
| Lecturers expenses and entertainment of guests | 54.50 | | |
| Notices and printing | 182.70 | | |
| Room rental and meeting expenses | 10.90 | | |
| Stenographic services | 40.00 | | |
| Flowers | 5.00 | | |
| Councillors expenses | 78.49 | | |
| Secretary's honorarium and expenses | 161.66 | | |
| Chairman's expenses | 9.00 | | |
| Publicity | 20.00 | | |
| Engineers Club dinner, etc | 102.00 | | |
| | | $684.25 | |
| Bank balance, January 5th, 1937 | | 504.55 | |
| | | | $1,188.80 |

The Branch also holds a Dominion of Canada $100.00 Bond.

Respectfully submitted,
O. HOLDEN, A.M.E.I.C., *Chairman.*
W. S. WILSON, M.E.I.C., *Secretary-Treasurer.*

## Vancouver Branch

The President and Council:—

On behalf of the Executive committee of the Vancouver Branch we beg to submit the following report of the activities of the Branch during the year 1936:—

### Meetings

Nine meetings of the Branch were held during the year and two inspection trips made as follows:—

1936

Jan. 29.—Annual Meeting(1935) held at the Grosvenor hotel. Speaker: J. P. Forde, M.E.I.C. District Engineer, Department of Public Works. New Westminster, B.C. Subject: **A Trip to Glacier Bay, Alaska, B.C.**

Feb. 3.—Joint meeting with the American Institute of Electrical Engineers, Vancouver Section. Held at the Medical Dental Auditorium. Speaker: Prof. E. G. Cullwick, Jr.E.I.C., Department of Electrical Engineering, University of B.C. Subject: **Hydro-Electric Development in Scotland.** (Illustrated.)

Feb. 27.—Dinner in honour of the President, Dr. Ernest A. Cleveland, M.E.I.C., at the Terminal City Club.

April 15.—Dinner meeting at the Grosvenor hotel. Speaker: Mr. W. D. McLaren, consulting engineer. Subject: **San Francisco Bridge.** (Illustrated.)

April 27.—Dinner meeting at the Grosvenor hotel. Speaker: D. O. Lewis, M.E.I.C. Subject: **A Study of the Physical and Operating Conditions of the Pacific Great Eastern Railway.** (This paper was published in the September Journal.)

May 5.—Meeting at the Medical-Dental Auditorium. Speaker: P. L. Pratley, M.E.I.C. Subject: **The Isle of Orleans Bridge.** (Illustrated.)

Sept. 21.—Meeting of the American Society of Electrical Engineers, Vancouver Section, to which the E.I.C. Vancouver Branch were specially invited, a large number availing themselves of the invitation. Speaker: Mr. L. W. Chubb, Director of Research, Westinghouse Electric Co., Pittsburgh. (Illustrated.)

Oct. 18.—Joint luncheon with the Canadian Institute of Mining and Metallurgy, B.C. Section. Luncheon held at the Spanish Grill, Hotel Vancouver. Speaker: Dr. E. A. Cleveland.

Nov. 23.—Annual Meeting (1936). Dinner at the Hotel Georgia. Guest speaker: R. Rowe Holland, Chairman of the Vancouver Parks Board.

### Inspection Trips

May 12.—Inspection trip to the British Pacific Properties West Vancouver, B.C., by courtesy of the British Pacific Properties Co.

Dec. 12.—Inspection trip to the Pattullo Bridge under construction across the Fraser River at New Westminster, B.C., by courtesy of Major W. G. Swan, M.E.I.C., consulting engineer on the project, and the Dominion Bridge Co. and the Northern Construction Co., general contractors.

All meetings and inspection trips were well attended.

The Executive committee held nine meetings during the year.

### Relations of the Branch with the B.C. Association of Professional Engineers

We are happy to report that there has been, as heretofore, a measure of close co-operation between the B.C. Association of Professional Engineers and the Vancouver Branch. As has been the custom for several years past, the President and the Registrar of the Association were appointed ex-officio members of the Executive committee and it has been found an excellent arrangement, particularly during the year 1936 when "Consolidation" matters affecting the interests of both groups were constantly under discussion. Mr. James Robertson, M.E.I.C., the Branch chairman, was also a member of the Association's Board during the year.

### Dr. E. A. Cleveland, President

The Vancouver Branch felt signally honored when it learned that one of its members, Dr. E. A. Cleveland, had been elected President of The Institute for the year 1936. Dr. Cleveland as an ex-officio member of the Vancouver Branch Executive committee has on a number of occasions made valuable contributions to the Committee's deliberations, on "Consolidation" matters particularly. These have been of great assistance and have been much appreciated by the Committee.

### Membership

The Resident and Non-Resident membership of the Branch shows an increase of nine members during the year. The membership of the Branch now stands as follows:—

| | Resident | Non-Resident | Total |
|---|---|---|---|
| Members | 64 | 16 | 80 |
| Associate Members | 44 | 31 | 75 |
| Juniors | 2 | 6 | 8 |
| Students | 12 | 9 | 21 |
| Affiliates | 1 | .. | 1 |
| | 123 | 62 | 185 |

### Walter Moberly Memorial Book Prize

The Walter Moberly Book Prize Award (value $25.00) for the year 1936 was awarded to Mr. Victor A. Zanadvoroff, a metallurgical student in the graduating year at the University of British Columbia.

### Consolidation Affairs

The Vancouver Executive committee have from time to time given much thought and study to Consolidation affairs. The Annual Meeting held at Hamilton in February was attended by Dr. Cleveland, E. A. Wheatley, M.E.I.C. (Registrar of the B.C. Association), Dr. Harry Letson, M.E.I.C. (President of the B.C. Association), and A. S. Wootton, M.E.I.C., Branch Councillor. Plenary meetings were also attended by Dr. Cleveland, Mr. Wootton and James Robertson, M.E.I.C., the Branch chairman.

From time to time these members returned with first hand information as to the progress of the Consolidation project.

Much correspondence, too, has passed between the Executive and the Committee on Consolidation during the year.

The Vancouver Executive feel that much excellent progress has been made towards the solution of this problem and are confident that in the near future the common objective will be reached that will be satisfactory to all the interested groups and in the best interests of the Profession in Canada.

### Employment

Employment conditions amongst engineers in the Vancouver District have improved greatly during 1936.

Briefly all registered engineers in geological, mining and metallurgical engineering are employed. There is much improvement in conditions affecting civil, mechanical and structural engineers. There is still, however, some distress amongst electrical engineers. Indications for 1937 are that all engineers will probahly be employed.

### Financial Statement

The financial statements of the Vancouver Branch for the period indicated are appended hereto.

#### General Account

| | | | |
|---|---|---|---|
| *Receipts* | | | |
| Bank balance, January 29th, 1936 | | $114.84 | |
| Rebates from Headquarters | | 237.50 | |
| Sale of old office furniture | | 6.00 | |
| | | | $358.34 |
| *Disbursements* | | | |
| Notices of meetings | | $ 64.22 | |
| Rental of auditorium | | 11.25 | |
| Rental of lantern | | 12.60 | |
| Administrative Expenses— | | | |
| Secretary's petty cash fund, etc | | 11.35 | |
| Rental of office | | 50.00 | |
| Stenographic services | | 15.00 | |
| Secretary's honorarium, 1935 | | 50.00 | |
| Complimentary dinner to President, February 28th— | | | |
| Expenses | $ 74.35 | | |
| Less receipts | 52.50 | | |
| Deficit | | 21.85 | |
| | | | $236.27 |
| Bank balance, Novemher 19th, 1936 | | | 122.07 |
| | | | $358.34 |

#### Walter Moberly Memorial Fund

| | | |
|---|---|---|
| *Receipts* | | |
| Bank balance, December 15th, 1935 | | $106.62 |
| Interest on $500 City of Vancouver 5% Bond, 1964 | $ 25.00 | |
| Interest on $100 Dominion of Canada 5% Bond, 1943 | 5.00 | |
| Interest on bank balances | 1.08 | |
| | | 31.08 |
| | | $137.70 |
| *Disbursements* | | |
| Charge for safe-keeping of securities, etc | $ 1.00 | |
| Bursar, University of British Columbia, Book award for 1936 | 25.00 | |
| | | 26.00 |
| Balance in bank, November 19th, 1936 | | $111.70 |

Audited and found correct:
Wm. O. Scott, M.E.I.C., *Auditor.*

Respectfully submitted,

James Robertson, M.E.I.C., *Chairman.*
T. V. Berry, A.M.E.I.C., *Secretary-Treasurer.*

## Victoria Branch

The President and Council:—

On behalf of the Executive committee we beg to submit the following report on the activities of the Victoria Branch of The Institute during the year 1936.

Meetings

Five general meetings of the Branch were held during the year, one of which was a luncheon meeting and one a dinner meeting, the average attendance being 27. Technical papers presented before the meetings were as follows:—

1936

Feb. 7.—**Air Mail Routes Through B.C.** by Major E. C. G. Chambers, A.M.E.I.C.

Nov. 4.—**The Island of Orleans Suspension Bridge Construction** by P. L. Pratley, M.E.I.C., Vice-President of The Institute.

On June 26th, the Branch was honoured by having as its dinner guest Dr. E. A. Cleveland, M.E.I.C., President of The Institute for 1936. Dr. Cleveland addressed the Branch on the proceedings of the last Annual General Meeting with respect to Consolidation.

Four meetings of the Executive committee were held during the year with an average attendance of 60 per cent. The only outstanding business coming before the executive was that pertaining to the proposed Consolidation of the Engineering Profession, in consideration of which this executive has endeavoured to work earnestly and diligently.

The annual meeting, which took the form of a dinner, was held on the 10th of December, at which the election of officers for 1937 took place. The meeting was followed by an illustrated address.

Membership

The membership of the Branch stands at sixty-four, a net gain of four members for the year. Two new Members and one new Associate Member were enrolled during the year; three Associate Members and one Student transferred to other Branches, two Members, one Associate Member, two Juniors and one Student were transferred to the Victoria Branch from other parts of Canada.

Employment

With regard to the employment situation there have been no calls during the year for financial assistance and the Executive has no knowledge of any members in need of such assistance. It would appear that general conditions are improving as at least three members of the Branch are known to have improved their position during the year.

In conclusion the Executive committee wishes to extend its sincere thanks and appreciation to the Secretary and Assistant Secretary at Headquarters for their unfailing assistance and courtesy during the year.

| | *Resident* | *Non-Resident* | *Total* |
|---|---|---|---|
| Members | 20 | 4 | 24 |
| Associate Members | 17 | 10 | 27 |
| Juniors | 4 | 1 | 5 |
| Students | 6 | 1 | 7 |
| Affiliates | 1 | .. | 1 |
| | 48 | 16 | 64 |

Financial Statement

*Receipts*

| | | |
|---|---|---|
| Balance on hand, December 13th, 1935 | | $128.42 |
| Rebates from Headquarters | $ 90.00 | |
| One Branch Affiliate's dues | 3.00 | |
| Collections, Annual Bridge Party | 5.50 | |
| | | 98.50 |
| | | $226.92 |

*Disbursements*

| | | |
|---|---|---|
| 1935 bills outstanding | $ 20.00 | |
| Mimeographing and letter service | 11.24 | |
| Stamps and stationery | 10.60 | |
| Services of stenographer | 10.00 | |
| Telephones and telegrams | 4.52 | |
| Cost of meetings | 1.50 | |
| Entertainment of guests | 4.75 | |
| Flowers | 4.00 | |
| Typewriter ribbon | 1.00 | |
| Cost of Annual Bridge Party | 10.90 | |
| Binding of Journals (2 vols.) | 3.50 | |
| Branch's share of representation at October 1936 Plenary Meeting | 68.30 | |
| 1935 honorarium to Secretary | 25.00 | |
| | | $175.31 |
| Balance in hand, December 10th, 1936 | | 51.61 |
| | | $226.92 |

Audited and found correct.

F. W. Knewstubb, A.M.E.I.C., Auditor.

Respectfully submitted,

I. C. Barltrop, A.M.E.I.C., *Chairman.*

Kenneth Reid, Jr.E.I.C., *Secretary-Treasurer.*

## Winnipeg Branch

The President and Council:—

The following report of the Winnipeg Branch for the year ending December 31st, 1936, is respectfully submitted.

Membership

The membership of the Branch is as follows:—

| | *Resident* | *Non-Resident* | *Total* |
|---|---|---|---|
| Members | 36 | 3 | 39 |
| Associate Members | 73 | 15 | 88 |
| Juniors | 13 | 4 | 17 |
| Students | 35 | 8 | 43 |
| Affiliates | 2 | .. | 2 |
| Branch Affiliates | 2 | .. | 2 |
| | 161 | 30 | 191 |

Meetings

There were fifteen general meetings of the Branch throughout the year, the attendance at the regular meetings averaging 73.

1936

Jan. 23.—Professor J. W. Dorsey, University of Manitoba, **High Voltage Low Current D.C. Transmission.** Attendance 62.

Feb. 6.—Meeting taken by the Student's Engineering Society of the University of Manitoba.
Mr. F. P. Findlay, **Bituminous Materials in Highway Construction.**
Mr. J. D. McKenzie, **Atmospheric Phenomena during Dust Storms, and their Effect on High Tension Wires.**
Attendance 39.

Feb. 10.—Annual supper dance, Winnipeg Branch E.I.C. and the Association of Professional Engineers of the Province of Manitoba, at the Royal Alexandria hotel.

Feb. 20.—Annual Meeting of the Branch. Mr. Frank Simmons, M.A.S.S.E., **Sewer and Water Lines in the Frozen North.** Attendance 61.

Mar. 9.—Dr. A. D. Blackhurst, **Scalebuoys, and Scale Removal from Boilers.** Attendance 77.

Mar. 19.—Meeting taken by Junior Engineer's Association.
Mr. Frank Dempsey, **Hard Surfacing of Highways.**
Mr. D. C. Brazier, **Creosoting.**
Attendance 51.

April 2.—Mr. Hew M. Scott, M.E.I.C., superintendent, Nelson River Construction Co., **Sewers in Tunnels.** Attendance 102.

April 16.—Prof. A. E. Macdonald, M.E.I.C., Professor of Civil Engineering, University of Manitoba, **Foundations on Unstable Soils.** Attendance 62.

May 11.—P. L. Pratley, M.E.I.C., **Island of Orleans Bridge.** Attendance 55.

Aug. 24.—Farewell dinner to Prof. J. N. Finlayson, M.E.I.C., at the Fort Garry hotel, in conjunction with the Association of Professional Engineers and the Engineer's Alumni Association.

Sept. 23.—Luncheon meeting to meet and hear President E. A. Cleveland, M.E.I.C., held at the Carleton Club.

Oct. 15.—Film **Noranda,** with introduction and comments by G. E. Cole, A.M.E.I.C., Director of Mines, Province of Manitoba. Attendance 160.

Nov. 5.—Film **Boulder Dam,** with introduction and comments by Mr. J. McMahon. Attendance 139.

Nov. 19.—Prof. R. O. Macfarlane, Ph.D., Department of History, University of Manitoba, **Secession Movements in Canada.** Attendance 38.

Dec. 3.—Meeting taken by Junior Engineer's Association.
A. Sandilands, Jr.E.I.C., **Engineering Generalities.**
Mr. T. A. Lindsay, **Recent Improvements in Telephone Communication Equipment.**
Attendance 26.

The Executive committee of the Branch held eleven meetings throughout the year.

Consolidation

Close co-operation continues between the Association of Professional Engineers of the Province of Manitoba, and the local Branch. The general strong desire for effective and prompt consolidation continues; members of the Association are mailed notices of all general meetings of the Branch. As will be noted by the financial statement. the Association has generously assisted the Branch to carry out this mailing and to provide light refreshments at the meetings.

Major A. J. Taunton, M.E.I.C., Chairman of the local Joint Committee on Consolidation, carried the Manitoba proposals on the subject to the Plenary Meeting of Council in October. The Manitoba proposals have been crystallized for more than a year. By continuing the previous good work of Councillor T. C. Main, A.M.E.I.C., Major Taunton was able to persuade Council of the reasonableness of these, to the extent that enabling clauses designed to allow the proposals to be put in effect, have been placed in the suggested revisions to Institute by-laws.

FINANCIAL STATEMENT

*Receipts*

| | | | |
|---|---|---|---|
| Bank balance, December 31st, 1935 | $140.82 | | |
| Less: Petty cash account | 6.04 | | |
| | | $134.78 | |
| Rebates of fees from Headquarters | | 270.62 | |
| Fees of Branch Affiliates | | 10.00 | |
| Grants, Association of Professional Engineers, Province of Manitoba: | | | |
| March 3rd, 1936 | $ 50.00 | | |
| December 31st, 1936 | 50.00 | | |
| | | 100.00 | |
| Bond interest | | 22.50 | |
| Bank interest | | .86 | |
| | | | $538.76 |

*Expenditures*

| | | | |
|---|---|---|---|
| Meeting notices, ballots, etc | | $171.49 | |
| Refreshments at meetings | | 45.25 | |
| Rent of room for meetings | | 11.00 | |
| Honorarium to retired Secretary | | 50.00 | |
| Honorarium to present Secretary | | 25.00 | |
| Student's prizes | | 20.00 | |
| Share of expenses of delegate to Plenary Meeting of Council | | 17.00 | |
| Affiliation with Manitoba Association for Adult Education | | 5.00 | |
| Engineering Journal, subscriptions of Branch Affiliates | | 4.06 | |
| Bank charges | | 1.55 | |
| Postage and excise stamps | | 6.03 | |
| Miscellaneous expense items | | 4.98 | |
| | | 361.36 | |
| Bank balance, December 31st, 1936 | $124.11 | | |
| Petty cash account | 3.29 | | |
| A.P.E.M. cheque received, December 31st | 50.00 | | |
| | | 177.40 | |
| | | | $538.76 |
| Accounts Receivable: Rebates due from Headquarters | | | $13.25 |

Certified a true and correct statement:

G. L. SHANKS, A.M.E.I.C.
D. M. STEPHENS, A.M.E.I.C. } Auditor.

Respectfully submitted,

G. E. COLE, A.M.E.I.C., *Chairman.*

H. L. BRIGGS, A.M.E.I.C., *Secretary-Treasurer.*

THE

# ENGINEERING JOURNAL

THE JOURNAL OF
THE ENGINEERING INSTITUTE
OF CANADA



VOLUME XX FEBRUARY, 1937 No. 2

## The Steam Locomotive of To-day

Readers of technical journals must have noted many recent references to the innovations and improvements in railway motive power which are being made by the railway administrations in Europe as well as in North America. Many of these are experiments on a large and expensive scale, their principal aims being reduction in operating costs and, what is even more important, an increase in the attractiveness of the passenger and freight services offered by the railways. Both these objects must be attained in substantial measure if the railways are to succeed in retaining, if not the lion's share of land transportation, at least a considerable slice of the business which offers or can be developed.

A number of these experimental changes in the character of railway motive power and equipment have now been in operation for a sufficient length of time to enable a judgment to be formed as to their results. For example, in England, the chief mechanical engineer of the London and North Eastern Railway, in a recent address, announced that as a result of the popularity of their high speed train services during the past twelve months a number of additional trains of this character will be put on during the coming summer, all timed at average speeds of from 65 to 67 miles per hour. A new train from London to Leeds will cover the distance of 186 miles in one hundred and sixty-five minutes. From the experience already gained Sir Nigel Gresley is convinced that these trains have very largely created their own traffic and have not drawn their passengers from existing services. They have proved profitable in operation; they demonstrate the possibilities of the steam locomotive and modern equipment if designers take advantage of the new materials now available and the advances made possible by present day technical knowledge. In France, Germany and the United States the experience has generally been similar, both in the case of steam-driven and internal-combustion-engined high speed trains. Trains of the former type running between Chicago and Minneapolis and St. Paul are operated by three roads and the public response as regards traffic results is understood to have been satisfactory in all three cases.

It is somewhat surprising to find that no very radical change in the conventional type of steam locomotive has yet proved its desirability in practice. The steam turbine and the water tube boiler have not yet come into their own for locomotive work. The successful locomotive boiler of today is built on the same general lines as the boiler of Stephenson's "Rocket," although it may be required in some cases to furnish steam for an engine developing 2,000 to 3,000 h.p. Among innovations in locomotive design which have proved acceptable are the superheater; in some cases the addition of a combustion chamber to the boiler, and the employment of modern valve gear in place of the old Stephenson link motion.

The designer of a modern steam locomotive has no easy task, particularly in Europe, where the permissible overall dimensions are so limited by tunnels, platforms and other permanent structures along the line. Not only must he provide for greatly improved performance, both as to capacity and economy, but this must be obtained without sacrificing any advantages due to the inherent simplicity and reliability of the machine. These are the qualities which, as Mr. Sillcox has pointed out, have enabled the steam locomotive, in spite of its lower thermal efficiency, to compete successfully with other more efficient but more complex types. Its lower first cost, maintenance and fixed charges, compensate in many cases for the higher fuel economy of its competitor.

In a paper published in this issue of The Journal and dealing with European railway motive power, attention is drawn to the remarkable results which have been obtained in France by the modernization of existing steam locomotives. Rebuilt locomotives, some of them twenty years old, have shown results comparable with those of new engines of the most modern type, both as regards increased speed of passenger service and greater fuel economy. These results have been obtained under the most severe conditions as regards limitation of first cost. Marked progress in locomotive design along similar lines has also been made in the United States, particularly as regards high speed, the record for the fastest steam train in regular service having now passed from the "Cheltenham Flyer" of the Great Western Railway in England, to the "Hiawatha" of the Chicago, Milwaukee and St. Paul road.

In Germany, France and other European countries, as well as in the United States, the problem of high speed passenger transportation has also been attacked in another way, namely, by the introduction of the light weight Diesel-electric train, designed so as to take advantage of the particular characteristics of the internal combustion engine. As regards the Diesel-electric trains of this type, it seems too soon to judge as to their economy in operation, but they have undoubtedly proved very popular in passenger service. In Germany, one of these trains, the "Fliegende Kölner," makes the run from Berlin to Hannover, 157.8 miles, in one hundred and fifteen minutes, a start-to-stop average of 82.3 miles per hour.

Comparison of the performances of such widely different types of motive power is not easy. For this purpose Mr. Lipetz proposes to use a figure which he calls "specific power factor," the ratio of horse power at the rail as determined on test, to the weight of the steam locomotive with half-loaded tender, or to the weight of the Diesel locomotive with full tanks, as the case may be. This ratio works out at from 8 to 12 in the latter case, and reaches nearly 20 in some of the modern steam locomotives.

There is no doubt as to the stimulating effect which the introduction of the Diesel locomotive has had on steam locomotive development. The resulting improvement in performance is only one example of the betterment which is now taking place in almost every branch of railway activity. The extent to which this is going on in North America is well shown in the exhaustive report* on railway equipment prepared for the Federal Co-ordinator of Transport, Washington, by his Mechanical Advisory Committee. The railways are determined to improve their services in every possible way to meet the new conditions. But while ready to consider any proposal for new equipment which promises the desired results, their past experience makes them cautious in departing widely from established trends of design.

## Committee on Consolidation

**Report for January 1937**

The report of the Committee for the year 1936, which appears elsewhere in this issue of The Journal, was presented and discussed at the Annual Meeting held in Montreal on January 29th. The meeting received and adopted the report and the seven recommendations of the Committee attached thereto, with the addition to recommendation No. 6 on the re-numbering of the By-laws, of the following phrase—"all such modifications thereof as Council may determine."

As was to be anticipated, the greater part of the discussion centred around Sub-section 7 (*b*), and the amendment thereto proposed by the Council. The Annual Meeting approved the clause as originally recommended by the Committee and in addition resolutions were received from the following Branches approving the Committee's 7 (*b*):—Victoria, Vancouver, Calgary, Lethbridge, Saskatchewan, Winnipeg, Lakehead, Niagara Peninsula, Hamilton, Toronto, Ottawa, Quebec, Saint John and Halifax. No definite decision was received from Montreal or Edmonton. No replies were received from Cape Breton, Moncton, Sault Ste. Marie, St. Maurice Valley, Peterborough, London or Border Cities. Kingston favoured the omission of Ontario from the provisions of this clause, and Saguenay favoured the Council's amendment.

A summary of the discussions of the Annual Meeting and of the resolutions received from the Branches of The Institute and from various Professional Associations, will appear in the March issue of The Journal.

The success which has marked this movement for closer co-operation between The Institute and the Professional Associations is in itself a demonstration of that spirit of co-operation which it is the aim of the profession to maintain and develop in the highest possible degree. Only the splendid support which your Committee has received from Branches of The Institute and from Provincial Professional Associations and the Corporation has made this achievement possible. The Committee expresses to these organizations and to the individual members of The Institute, its deepest appreciation and thanks for their encouragement and fine co-operation.

When, as a member of The Institute, the opportunity comes to you to express your wishes in this important matter, you may add your personal co-operation through the sending in of your ballot. Every member should VOTE.

Gordon McL. Pitts,
*Chairman.*

*See notice, p. 103.

## Semicentennial Committee

A. Cousineau, A.M.E.I.C.
R. L. Dobbin, M.E.I.C.
J. M. Fairbairn, A.M.E.I.C.
R. H. Findlay, M.E.I.C.
F. S. B. Heward, A.M.E.I.C.
J. L. Busfield, M.E.I.C., Chairman

## PROGRAMME

(Subject to Revision)

**TUESDAY, JUNE 15th, 1937**

Registration, at Windsor Hotel, Reception, Presentation of Addresses, Greetings and Honorary Memberships.

Opening Luncheon.

Presentation of Technical Papers and Discussions.

Reception and Supper Dance.

**WEDNESDAY, JUNE 16th, 1937**

Presentation of Technical Papers and Discussions, continued.

Luncheon.

Presentation of Technical Papers and Discussions, continued.

Banquet—His Excellency the Governor-General of Canada, Lord Tweedsmuir, guest of honour. This function will probably be connected by telephone circuits with the twenty-five branches of The Institute. It is also hoped that greetings will be heard direct from England, India, Australia, South Africa and New Zealand.

**THURSDAY, JUNE 17th, 1937**

Visits to points of technical and general interest in and around Montreal. Arrangements will also be made for those who wish to play golf. Garden Party.

Smoking Concert. Ladies' Bridge Party.

**FRIDAY, JUNE 18th, 1937**

Transportation to Ottawa, Ont.

Luncheon at Ottawa.

Visits to points of technical and general interest in and around Ottawa.

Dinner Dance. Conclusion of main programme.

The Ladies' Committee will arrange special entertainment for visiting ladies.

# The Engineer in Business

## Address of the Retiring President

*E. A. Cleveland, M.E.I.C.*

Delivered before the Fifty-First Annual General Meeting of the Engineering Institute of Canada, Montreal, January 29th, 1937.

You have had before you the reports of Council and of the Finance Committee for the year 1936. Considering the times through which we have been passing you will doubtless all agree that the position of The Institute has been well maintained. An increase in membership and in revenues even though the latter has been accompanied by increased expenditures is a significant sign of progress.

The reports of the various Committees, together with those of the Branches, attest the lively interest taken in Institute affairs, as well as the activities of the Branch organizations in matters affecting the public welfare and the work of The Institute in promoting the interchange of professional knowledge.

Inasmuch as the labours of the Committee on Consolidation have dealt with a problem that has a vital bearing on the whole future of The Institute that Committee's report will be received with more than usual interest. It is confidently hoped that every member of The Institute will give to the report and to such action as may be taken thereon at this meeting his most careful and conscientious consideration.

I take this opportunity of extending to all the Committees and the officers of the Branches, the thanks of the membership at large for splendid services freely given. Few realize fully the extent of the time and ability voluntarily bestowed, particularly at Headquarters, on the work of The Institute. To the General Secretary and his able staff I extend the thanks of every member of The Institute for their undivided attention and loyalty to its interests.

May I say a personal word of appreciation of the privilege I have enjoyed in serving for the year as your President. The conquest of science and engineering over time and space has hardly been complete enough to permit a man from the farthest West to be at Headquarters sufficiently long and often to do full justice to his responsibilities. To the Vice-Presidents and members of Council who have so kindly acted as proxies and ably filled the gaps my most grateful thanks are tendered.

It is customary for the retiring President to make an address upon or some allusion to recent progress in engineering. As that subject will be so fully dealt with at the forthcoming Semicentennial of The Institute in June I am furnished with an adequate excuse, though perhaps not full justification, for addressing you briefly upon another subject: that of the Engineer in Business.

The call of business upon the engineer has always been more or less insistent, particularly to those whose intellectual qualities include an aptitude for acquisition, a regard for material values and what may be termed the trader's instinct. During the period of depression, which is now making a leisurely retreat, the urge of engineers to engage in business has probably embraced many whose dominating interests have been deflected and redirected by circumstances, from applied science to the solution of more personal problems.

Business is spoken of here in the general sense not only of the trading in commodities for gain and in the transformation of one kind of commodity into another as in industry, with the same motive, but also as including occupations involving constant public contacts and relations of a non-professional nature.

The general assertion that engineers are poor business men has been often made and leads one to enquire as to whether it has a foundation in fact. The statistical basis for such an enquiry is probably not available. The ratio of the number of engineers in business to the number of all other classes of men so engaged may for a community or a country be obtainable but could not in any event take account of the peculiar relation of the engineer, as a professional man, to business. His position in many cases as professional adviser makes it quite impossible to break down his advice into those elements that are distinguishable as engineering and those that may be classed as business. The considerations that enter into a certain recommendation may involve a complete knowledge on the part of the engineer of the methods of operation and costs of machinery and equipment to fabricate or produce a certain commodity and alternatively the practicability of the production of modified, enlarged or entirely new types of machines to accomplish a specified end. Since the purpose of business is to make profit, the specified end almost invariably is to produce a better commodity at the same cost or the same commodity at a lower cost than hitherto. The creative mind that produces a new and novel mechanical device or devices, or a new technical process, may be quite capable of comparable originality in the field of business.

The startlingly original engineering advice given to owners of early gold mines on the Rand to sell their properties on the outcrop of the reef and to acquire land on the dip was founded on a thorough engineering appreciation of the difficulties of deep mining and the methods to be employed to effectively overcome them. It grew, however, out of the belief, born of experience and good judgment, that to sell developed ground and to buy virgin ground in which few had any confidence would be profitable business.

The great enterprises that have been built upon the production of cheap power from hydro-electric or fuel sources and the vast business of power production, transmission and distribution, have been correlated on the foundation of engineering advice wise in its awareness of the business aspects of these complicated inter-relations.

A review of some of the major enterprises in these categories will disclose instances where a succession of undertakings had its inception in the mind of an engineer. The investigations not only compassed the engineering possibilities of a power site or series of sites capable of economic development, but embraced a whole congeries of more or less unrelated projects. Engineering knowledge coupled with business discernment indicated the combination as a profitable market for power and profitable alike to the industries to be established. Thus have flourishing communities, towns and young cities been created. What higher type of business ability can be found than that displayed by engineers who not only initiate such enterprises, but as managing heads carry them through over a long period of years in progressive stages of development as market demand grows or is created?

The amazing development of the automobile business is displayed not only in the technical perfection of the machine and its growing usefulness and appeal, but also in the mass production methods that have by the use of improved materials and equipment increasingly permitted the production of better cars at lower prices. This has been based not alone on technical achievement but also upon the sagacity of engineers whose business ability permitted them, in their wide survey of aims and perfections still unaccomplished, to choose for each year's progress those things that were practically well enough advanced to serve the market. What keener type of business sense could be evoked? Indeed in this great industry engineering has given to business some of its brightest minds.

This is not less true of the transportation business, where some of the great railways are headed by engineers of recognized capability and of proven business judgment and ability. The recent large improvement in railway passenger traffic has been an engineering achievement. Streamlined engines and trains, the steady approach toward a higher degree of perfection of the internal-combustion locomotive and air-conditioned cars could scarcely have arrived save as the engineer visualized them as an answer to the drooping curve of railway passenger business. His share in the operation of these means of locomotion in the great business of transportation is not confined solely to a care for the precision and certainty of their operation, but as well to their reactions on the travelling public and their adequacy for the intended purpose. He would seem to be doubly a business man who discerns the need for the resuscitation of a failing business and at the same time commands the technique for the creation, development and improvement of the means to achieve that end.

It is appropriate to allude to one of the newer businesses, that of motor-bus transportation, a factor of considerable importance in the drop in railway passenger revenues just referred to. Here the engineer through his knowledge of the major technical factors involved may be discovered directing or assisting in management.

One needs but to observe some of the other important businesses of the world to note that the engineer is playing his part in them. The great chemical, metallurgical and oil industries where not only plant but intricate processes of manufacture are a predominant care and interest of the business administration find engineers emerging into management.

In the realm of the relations between employer and employee instances may be found of engineers of great ability and scientific attainments, combining in a marked degree qualities of humanitarianism and business acumen, who have shown to belligerents both in the fields of capital and labour that the best business for all results when some of the profits of industry are shared with labour according to pre-arranged and specified plans.

The construction of great public works, running into many millions and occasionally hundreds of millions of dollars, will generally be found entrusted to men who combine engineering skill and business ability. They are noteworthy men in whose judgment governments and other public bodies deem it wise to leave the management of construction and frequently the direction and operation of the completed works. The actual construction of this class of large undertakings demands the exercise of the highest talents. A scale of operations in size and speed of hitherto unequalled dimensions frequently requires new and untried equipment and fresh methods of attack. The correlation of many large sized and divergent operations limited by strict time schedules, the purchase of machinery, equipment and supplies in large quantities, the housing and feeding of thousands of men, the preservation of good relations with the public and their representatives through whom funds are supplied and with the staff, trained men of many kinds and labour generally, the cost-keeping and accounting, all imply the skilled use of the methods and appliances of big business.

Engineers are frequently to be found at the head of great electrical and other public utilities where intimate knowledge of engineering matters is a pre-requisite. A sound knowledge of business gained generally through gradual emergence from strictly engineering departments to management is a not unusual characteristic of such leaders in business.

Public utility commissions, where the determination of what is fair demands rational analyses of both tangible and intangible elements as factors in costs in rate-making and other problems, constitute a fertile field for engineers. Public confidence in the protection afforded through this necessary sort of over-lordship is not alien to its recognition of the value of sane combinations of engineering and business ability often observable in these highly responsible positions.

And in the profitable and highly organized business of dealing in money and credit the engineer has left his impress. In the highest positions in banking and on the directorates of banks and other large financial institutions are to be found men whose knowledge of and respect for detail as well as of and for broad principles alike in engineering and in business has made them important figures in business life.

City managership has provided engineers with opportunities of demonstrating that administrative and executive positions may be acceptably filled by engineers. An understanding of the mechanisms of the public works and utilities of a city, with the ability to dissect and interpret a balance sheet and other forms of financial records and operations, is a stepping stone to useful public service. Experience in the handling of men in engineering work may be soundly applied to the sometimes slower moving forces of a city.

Toward the important business of government engineers have not displayed notable ambition. Our great neighbour to the South has twice filled her highest elective office from their ranks: in the days when military engineering was still the mother engineering art and again when the choice fell upon a man of international reputation as a mining engineer and executive. In our own country the engineer appears to be generally disinclined to offer his services in the arena of politics. Possibly his mental habit of getting things done is irked by the contemplation of the interminable aspect of the affairs of government. There have been, however, of late years two well-known engineers at the heads of important departments of Federal Government and a similarly small representation in provincial cabinets. It is to be hoped that these may be looked upon as successful precedents in a career where enrichment of the public service should override the unalluring aspects of a political campaign.

As permanent heads and in less conspicuous positions in government departments are to be found splendid examples of efficient engineers as public officers. The duties of such positions are not more difficult nor the services rendered less effective because the incumbent happens to blend talents for administration with knowledge of engineering. Precedents such as these should act as a spur to those whose inclinations are in the direction of public service.

Moreover there is the multitude of small businesses, in the conduct of which engineering training, even where not essential, is an added advantage. In them, equally with those of larger amplitude, the training in and appreciation of the principles which underlie economic judgment afford their possessor a certainty in decision that may often be denied the less fortunate.

For a world where technologic advance has outstripped social progress special facilities should be developed to train engineers for social and business leadership. In the education of engineering students some methods of selection might be evolved that would set apart for special training in human relations those whose aptitudes for leadership are well marked. This formal training should be the foundation upon which to rear a knowledge and understanding of men and the ability to appraise their qualities. These are among the prime elements of success in business and are to be gained only by wide personal contacts with many sorts and conditions of men.

This brief recital of some of the avenues of business along which engineers have progressed may help younger members of The Institute to dispel an inferiority complex in respect of the fitness generally of engineers to engage therein.

They too may share in the spirit of the Happy Warrior of Wordsworth:

"It is the generous spirit, who, when brought
Among the tasks of real life, hath wrought
Upon the plans that pleased his childish thought;
Whose high endeavours are an inward light
That makes the path before him always bright;
Who with a natural instinct to discern
What knowledge can perform, is diligent to learn."

## OBITUARIES

### Francis Thornton Cole, M.E.I.C.

The membership of The Institute will learn with regret of the death on August 28th, 1936, at Quebec, of Francis Thornton Cole, M.E.I.C.

Mr. Cole was born at St. Catharines, Ontario on July 8th, 1884, and graduated from McGill University in 1910, with the degree of B.Sc.

Following graduation, Mr. Cole joined the staff of the Dominion Bridge Company, and in 1910-1911 was engaged on draughting, designing and estimating various structures and in 1912 he was resident engineer for the company in Toronto. In 1913 Mr. Cole was appointed chief engineer of the Eastern Canada Steel Company, being in charge of all structural steel contracts for the company, among which were St. Anne's College at St. Anne de la Pocatière, and structures in Quebec city such as the exhibition grand stand, the steel trestle for the Terrace, sheds for the Harbour Commission, etc., and also many highway bridges for the Provincial government. Mr. Cole held this position until the time of his death.

He joined The Institute (then the Canadian Society of Civil Engineers) as a Student on October 8th, 1908, became a Junior on October 14th, 1913, an Associate Member on January 18th, 1917, and a Member on April 22nd, 1919.

### Joseph Labelle, A.M.E.I.C.

It is with deep regret that we place on record the death by drowning in St. Mary's Current, on December 17th, 1936, of Joseph Labelle, A.M.E.I.C., of Montreal.

Mr. Labelle was born at Montreal on November 24th, 1879, and graduated from the Ecole Polytechnique in 1903 with the degree of B.A.Sc. Following graduation Mr. Labelle was until 1905 with the Buoy Service of the River St. Lawrence Ship Channel, when he became connected with the Locomotive and Machine Company. In 1907 Mr. Labelle was with the Standard Construction Company, subsequently working on the staffs of the Structural Steel Company and the Dominion Bridge Company. In 1925 he entered private practice as a consulting engineer, and in 1933 joined the staff of the Montreal Water Board.

Mr. Labelle joined The Institute (then the Canadian Society of Civil Engineers) as a Student on April 23rd, 1903, and became an Associate Member on April 17th, 1909.

### Denis Lemieux, S.E.I.C.

It is with great regret that we record the untimely death by electrocution on July 30th, 1936, of Denis Lemieux, S.E.I.C.

Mr. Lemieux was born at Quebec, Que., on November 2nd, 1909, and having obtained the degree of B.A. cum laude from the Seminaire de Quebec in 1931, graduated from the Ecole Polytechnique in 1936 with the degree of B.A.Sc.

In the summer of 1933 Mr. Lemieux was a roads inspector for the city of Montreal, and in those of 1934 and 1935 he was with the Road Department of the Province of Quebec. At the time of his death, Mr. Lemieux was on the staff of the Canadian General Electric Company at Toronto, Ontario.

He became a Student of The Institute on March 6th, 1936.

### James John Humphreys, M.E.I.C.

It is with regret that we place on record the death at Montreal on January 24th, 1937, of James John Humphreys, M.E.I.C.

Mr. Humphreys was born at Bayonne, N.J., on March 22nd, 1871. In 1886-1889 he was assistant to the superintendent of the Bayonne and Greenville Gas Company, and then was a cadet engineer on electric plant and gas works construction with the United Gas Imp. Company at Kansas City, Mo. From 1891 to 1893 he was assistant superintendent on gas works construction and operation for the same company at Waterbury, Conn. In 1893 Mr. Humphreys came to Canada as secretary-treasurer and general manager of the Ottawa Gas Company, but in the same year he was appointed general manager of the Westchester Gas Company, in Pennsylvania, and remained with that company until 1897, when he became superintendent of the Worcester Gas Company at Worcester, Mass. In 1902 Mr. Humphreys was appointed general manager of the Brooklyn Borough Gas Company at Coney Island, N.Y., and in 1910 he became general manager of the Louisville Gas Company at Louisville, Ky. In 1914 Mr. Humphreys was general manager of the Augusta Gas Company at Augusta, Georgia. From 1915 until 1917 he was superintendent of shell shops for the Linderman Machinery Company in Michigan, and with the McKinnon Dash Company at St. Catherines, Ontario. He then joined the 7th Regiment, New York, and was transferred to the Ordnance Department serving as liaison officer between the United States, France and Great Britain in 1917 and 1918. On his return he joined the staff of the Montreal Light, Heat and Power Company as gas engineer. Mr. Humphreys was later appointed gas engineer with the gas department, which position he held at the time of his death.

Mr. Humphreys joined The Institute as a Member on April 2nd, 1929.

### John Wilbert Purcell, A.M.E.I.C.

Regret is expressed in placing on record the death at Toronto, Ontario, on January 6th, 1937, of John Wilbert Purcell, A.M.E.I.C.

Mr. Purcell was born at Listowel, Perth county, Ontario, on February 29th, 1872. From 1892 to 1896 Mr. Purcell was with the Detroit Electric Light and Power Company, and from 1896 until 1912 he was engaged on superintending the installation and the operation of the electrical plant of Hiram Walker and Sons. In 1912 Mr. Purcell joined the staff of the Hydro-Electric Power Commission of Ontario, first as assistant engineer, and then as electrical engineer, which position he held at the time of his death.

Mr. Purcell became an Associate Member of The Institute on September 20th, 1921.

## PERSONALS

F. G. Rutley, A.M.E.I.C., vice-president of the Foundation Company of Canada Limited, Montreal, was elected for a second term as president of the Canadian Construction Association at the annual convention of the Association held recently in Ottawa, Ont.

Mr. Rutley graduated from the University of Toronto in 1912 with the degree of B.A.Sc. and following graduation was for a time instrumentman on a field survey for the Alberta Interurban Railway Company, Calgary, Alta. In 1913 he became designer and field engineer on a water power development at Kananaskis Falls, Alberta, for the Calgary Power Company Limited, and in 1914 he joined the staff of The Foundation Company as resident engineer, which position he held for some years, acting for the company on the construction of the Magnetewan River bridge, and the Shaws Creek bridge on the Canadian Pacific Railway, the steam power house for the Dominion Iron and Steel Company at Sydney, N.S., a man shaft for the Dominion Coal Company at Glace Bay, and many other important works. Mr. Rutley next became secretary of the company and assistant to the general manager, subsequently becoming purchasing agent, assistant general manager, and in 1931 vice-president of the company.

J. Colin Kemp, A.M.E.I.C., has been appointed to assist in the organization of the Home Improvement Plan in the Province of Quebec. Mr. Kemp, who is a former executive of the National City Company at Montreal, was also for some time in private practice as a consulting engineer. More recently he has been assistant to the president of Dominion Stores Limited.

A. Ritchie, A.M.E.I.C., is now associated with the Whiting Corporation (Canada) Limited, at Toronto, Ontario. Mr. Ritchie, who was formerly chief engineer of construction with the city of Edmonton Power Plant, at Edmonton, Alta., was at one time Service and Research engineer with the Riley Engineering and Supply Company, Limited, Toronto, Ontario.

**C Kirkland McLeod, A.M.E.I.C., Becomes Alderman**

C. K. McLeod, A.M.E.I.C., was recently elected by acclamation as alderman for the City of Westmount, Que. Mr. McLeod graduated from McGill University with the degree of B.Sc. in chemical engineering in 1913, and immediately following graduation became plant chemist with the Canada Cement Company Limited, remaining with that organization for the next three years. From 1916 to 1919 he was engaged on the inspection of explosives with the Imperial Ministry of Munitions. In May 1919 Mr. McLeod was appointed chief chemist for the Dominion Glass Company, and a year later became superintendent

C. K. McLeod, A.M.E.I.C.

with the Consumers Glass Company. In May 1921 Mr. McLeod was with the Phoenix Bridge and Iron Works on design and sales of structural steel work. When this firm was taken over in October, 1923, by Canadian Vickers Limited, he occupied a similar position with the new organization. Since 1925 Mr. McLeod has represented the Permutit Company, Walter Kidde and Company and the American Hard Rubber Company in Eastern Canada, first as manager of the Chemical Engineering Equipment Company, then as a principal of Busfield McLeod Limited, and in 1934 he entered into business under his own name representing the same interests.

Mr. McLeod is very well known to the membership of The Institute as Secretary-Treasurer of the Montreal Branch. He has held this onerous office for ten years, and his resignation was accepted with great regret at the last meeting of the Executive Committee of the Branch. Mr. McLeod felt obliged to relinquish this secretarial work in consequence of the civic duties which he has now undertaken.

C. E. Frost, A.M.E.I.C.

Clifford E. Frost, A.M.E.I.C., was elected chairman of the Junior Section of the Montreal Branch of The Institute at the Annual Meeting of the Section held on January 18th, 1937. Mr. Frost graduated from McGill University in 1931 with the degree of B.Sc., and since that time has been an assistant engineer on the staff of the Harbour Commissioners of Montreal.

H. Massue, A.M.E.I.C., was elected chairman of the Montreal Branch of The Institute for the coming year, at the Annual Meeting of the Branch held on January 7th, 1937. Mr. Massue graduated from Laval University in 1913 with the degree of B.A.S., and following this was for eight months in 1914 at the Massachusetts Institute of Technology. Returning to Montreal Mr. Massue became connected with the Quebec Streams Commission, remaining with that organization until 1928, when he joined the staff of the Shawinigan Water and Power Company, Montreal, as assistant engineer.

## ELECTIONS AND TRANSFERS

At the meeting of Council held on January 19th, 1937, the following elections and transfers were effected:

*Member*

NARIMAN, Rustum Kaikhushro, A.C.H., (Royal Indian Engrg. College), consltg. engr., Sapper Lines, Secunderabad, India.

*Associate Members*

DEWAR, Charles Leonard, B.Sc., M.Sc., (McGill Univ.), outside plant and transmission engr., Bell Telephone Company of Canada, Montreal, Que.

GORDON, Harry J., B.Sc., (McGill Univ.), sales engr., Fred Thomson Co. Ltd., Montreal, Que.

KELLY, William Henry, B.Sc., (McGill Univ.), supt. in charge of logging operations, Buckingham, Que.

*Juniors*

HENRIKSON, Gunnthor John, B.Sc., (Univ. of Man.), Selkirk, Man.

JARRELL, Gordon James, B.A.Sc., (Univ. of Toronto), inspr., Beatty Bros., Fergus, Ont.

LAUGHTON, James Alexander, B.Sc., (Univ. of Man.), engr., Canadian Brown Steel Tank Co. Ltd., Brandon, Man.

*Transferred from the class of Associate Member to that of Member*

ASKIN, Robert J., B.Sc., (Queen's Univ.), mgr., Thunder Bay Paper Co., Port Arthur, Ont.
HOWRIGAN, Clyde Paige, mgr., Aranka Gold Mines, British Guiana. (Home) Bakersfield, Vt.

*Transferred from the class of Junior to that of Associate Member*

McILQUHAM, Walter Scott, B.Sc., (Queen's Univ.), engr., Dominion Engineering Works Ltd., Montreal, Que.

*Transferred from the class of Student to that of Associate Member*

JEHU, Llewelyn, Jr., B.Sc., M.Eng., (McGill Univ.), designer, Dominion Bridge Co. Ltd., Montreal, Que.
KING, Peter Campbell, B.Sc., (Queen's Univ.), laboratory instructor, Queen's University, Kingston, Ont.

*Transferred from the class of Student to that of Junior*

ANDERSON, Roderick Victor, B.A.Sc., (Univ. of B.C.), asst. refinery engr., Tropical Oil Co., Barranca, Bermeja, Colombia, South America.
FRANCIS, John Barten, B.Sc., (McGill Univ.), engr., Canadian Industries Ltd., Montreal, Que.
FRASER, Ralph Percy, B.Sc., (Univ. of Man.), junior voltage tester, Winnipeg Electric Company, Winnipeg, Man.
MacPHERSON, John Miles, B.Sc., (Univ. of N.B.), instr'man., N.B. Highway Dept., North Devon, N.B.

*Students Admitted*

BRICELAND, Emmett Vincent, (Queen's Univ.), Kingston Junction, Ont.
BROWN, Donald Whidden, (Queen's Univ.), 196 Stuart St., Kingston, Ont.
CLAIRMONT, Adolphe, B.A.Sc., C.E., (Ecole Polytechnique, Montreal), 198 St. Charles St., St. Johns, Que.
CUNNINGHAM, Donald David MacCoubrey, B.Sc. (E.E.), (Univ. of N.B.), 21 Lowell St., West Saint John, N.B.
DESJARDINS, Roger, (Ecole Polytechnique, Montreal), 1621 St. Hubert St., Montreal, Que.
DURANCEAU, Charles Arthur, (McGill Univ.), 3480 Harvard Ave., Montreal, Que.
HOPKINS, Alfred, B.E. (E.E.), (N.S. Tech. Coll.), Canadian Westinghouse Company, Hamilton, Ont.
MOTHERWELL, Charles Gordon, (McGill Univ.), 574 Cote St. Antoine Road, Westmount, Que.
McMILLAN, Thomas Stewart, (Univ. of N.B.), University of New Brunswick, Fredericton, N.B.
SCHEEN, Marcel, (Ecole Polytechnique, Montreal), 1230 St. Hubert St., Montreal, Que.
SCOTT, James Munroe, (Univ. of N.B.), University of New Brunswick, Fredericton, N.B.

## CORRESPONDENCE

Vancouver, B.C., January 26, 1937

The Editor,
The Engineering Journal.

Dear Sir,

Having been associated with The Engineering Institute of Canada and its predecessor for nearly thirty years I am one of the oldest members in British Columbia. I should like to claim the privilege of expressing my views on consolidation and ask for them the same publicity as has been given to contrary opinions. That I was also an active worker in favour of the B.C. Engineering Act, a Member of the B.C. Association Council in 1920 and in 1931, should indicate that I am unprejudiced as between the two bodies. As I am not in favour of anonymous publications I ask that my name be attached.

The Dominion of Canada has nine provinces, in each of which, with the exception of Prince Edward Island, there is an Assoeiation of Professional Engineers. As under the Dominion constitution the control of any professional body is solely a provincial affair, these associations can never be amalgamated or consolidated into a single unit. But why should not the requirements for registration be the same in all the provinces?

The answer is, first, that within each province the engineers themselves have not been unanimous; second, legislatures look on professional Acts, especially engineering, as class legislation, and insofar as a dissatisfied voter is more potential dynamite than a dozen complacent non-voluble engineers, they will pay more attention to that class of citizen than they will to any claim based on the "protection of the public." As long then as the Professional Associations remain individual with entirely different legal requirements for membership, entirely different educational requirements, entirely different professional training requirements, so long will professional engineers remain in the morass. Engineers early recognized this fact and in 1919 The Engineering Institute of Canada, at its own expense, called together representative engineers from all the provinces and formulated the "Model Act" with the hope that each province would adopt the principle. Expediency required divergence here and there, so that few of the eight provincial Acts are an exact copy of the model.

The Act in British Columbia, due to its legislatures both Liberal and Conservative being more progressive than in the other provinces, has probably surpassed other acts in stringency. British Columbia has also probably placed more stress on entrance requirements than have the others. Obviously it is desirable that there should be reciprocity between the provinces, i.e. an engineer registered in one province should be acceptable without proof of education or professional standing in any other province.

If all standards of education and professional experience were the same, British Columbia's Council would not then have to admit, because of diplomatic reasons, men of qualifications inferior to its own requirements. To accomplish this ideal spasmodic efforts have been made. In 1926 Mr. Geo. Walkem, President of The Engineering Institute and also President of the Professional Association, did a prodigious amount of work on the subject. On his retirement the matter lapsed. It was resurrected to some extent in 1931 when I was a member of the Board. Finally there was set up a Council of Four, then a Council of Eight, composed of members of the various Provincial Associations. But in all the years of their existence they did not evolve a single constructive suggestion which could be put before the various Provincial Associations even as a Report of Progress.

The Engineering Institute of Canada at its meeting in January, 1935, observed the stagnation and appointed a committee on Consolidation. In 1936 at Hamilton this committee reported. Two members of the Council of Eight were added to the committee on consolidation. A plenary meeting of The Institute Council in conjunction with the Committee on Consolidation met in Montreal in October, 1936, and set up a proposed set of by-laws which, if accepted, will completely change the constitution of The Institute, so that it will become the consolidation factor in the Provincial Associations around which could be developed uniformity of laws and professional requirements. Discussion at the E.I.C. General Meeting in Montreal on January 29th and 30th will be followed by a ballot of the whole corporate membership of The Institute.

Now a small body of engineers has taken exception and violent objection to the proposed consolidation. That is to be expected, as in my experience never at any time has there been complete unanimity on the Engineering Act or its amendments.

In 1920 the passage of the B.C. Engineering Act was disapproved by many of the same group. In 1924, 1925, 1926, 1929 and 1930 the Committee on Amendments had to compromise or withdraw much needed reforms in the Act, and in 1933 this same opposition was so virile that the whole amendment scheme was dropped and has not since been brought up. All disadvantages of the proposed consolidation scheme will be advanced by that body of objectors and so I will set forth what to me seems the evident advantage of the new setup. I quote the aims and objectives of The Engineering Institute of Canada "To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public." The highest professional consideration is the basis of its objectives—no thought of petty bickering of one branch of engineering with another, no thought of exploitation by its members of the public. Can we suggest higher ideals? To achieve them depends entirely upon the ethical standards of the members. After reading the list of the Presidents, Vice-Presidents, Councillors and Members of The Institute since its formation in 1887 no person need worry over a let-down of professional standing by The Engineering Institute of Canada.

The Registered Engineers in the various provinces are in the main not different from the members of The Engineering Institute of Canada. We would therefore not expect to find any deterioration in professional standing because of adherence to one organization or the other. It is felt that the years will remedy any substandard condition that may exist and that minimum professional requirements and a well observed code of ethics will convince the public that Canadian Engineers are all properly qualified.

The scheme of consolidation proposed by The Institute is at least a scheme. No other body has proposed seriously any alternative. If there is not complete satisfaction amendments can be made in accordance with the will of the majority. That perfection is not always reached on the first effort is evidenced by the fact that since 1920 there have been five changes in the B.C. Engineering Act. More are needed. But we must all admit that this Act of 1920 was infinitely better than no Act at all, and so is the consolidation scheme outlined by The Institute. Accept it, amend its inconsistencies from time to time, but get something started.

The Institute has been developed to include all branches of engineering. Mining, electrical, mechanical, chemical and other branches of engineering have their own associations dealing with their own problems and some of these engineers advance the argument that an all-including Institute is not necessary and that The Engineering Institute should confine itself to civil engineering only. May I point out that civil engineering is divided into many subdivisions each of which is probably as large in the number of its members as the usually named more general branches of engineering. An engineer under any one of these subdivisions must unite with others to disseminate the literature and knowledge of that particular calling. But that does not preclude him from sympathetically assisting the other broader field covered by The Institute.

For fifty years The Institute has been looked upon as a leader in the engineering profession. When new legislation or amending legislation is required the prestige of these years is something that cannot be overlooked in the provincial fields. To many members of legislatures it is the hall mark of perfection. Do not discard this winning card for the sake of holding a joker whose unmasked features can only disclose the face of prejudice. In other provinces The Institute is not held in the Holy Horror that some of our registered men in British Columbia seem to have for it.

Notwithstanding some members' claim that The Institute has never accomplished much (which view can only be held by one who has accomplished nothing for The Institute) The Engineering Institute for fifty years has catered to the professional welfare of Canadian engineers from coast to coast. The amount of time and money it has spent on efforts to better the engineering profession cannot be defined in dollars.

Another and more widespread contention, that the component associations' representatives of one councillor from each association would be swamped by the branch councillors is entirely a misconception, for in the past ten years probably ninety per cent of the councillors have been registered in the provinces they represented. Can you imagine Wootten, Swan Buchan, Walkem and hundreds of others as selling the Associations 'down the river'?

And finally, The Engineering Institute of Canada is Canadian. Whether native born or immigrant, our living in engineering is made in Canada and if we cannot support an all-Canadian organization we should at least keep quiet on the subject.

At a Pittsburgh dinner a few days ago Myron Taylor, Board Chairman of the United States Steel Company, spoke the following words, except those in italics which I have paraphrased:

> "I have faith that if patience is invoked, if all prejudice and ill feeling are discarded, if honest intention to co-operate predominates, if self-interest is subordinated to the common good, we can and must, through common effort... accomplish that equitable relationship between the *Provincial Associations, The Engineering Institute of Canada and other technical or scientific organizations* which will solve our existing *professional* discord."

Let us accept that thought and get along with our professional improvement.

W. H. Powell, M.E.I.C.

L'Assomption,
January 13th, 1937.

The Editor,
The Engineering Journal.

Dear Sir:—

I join with all engineers in rejoicing over the recent election of C. K. McLeod, A.M.E.I.C., to the Council of the City of Westmount. Surely, any municipal administration is to be congratulated on having that fine type of citizen at the helm.

Besides being a level-headed and public-spirited citizen, Mr. McLeod is also a very prominent member of our profession. Was any mention made of that in any of our newspapers? Both the "Montreal Star" and "Le Canada" published photos and a short write-up, but neither mentioned the fact that he is an engineer. Where was our publicity committee?

We, as engineers, are often accused of not taking a sufficient part in the legislative domain. But when some member of the profession storms the bulkwarks the public isn't even told he's an engineer. I am not in the least suggesting that this should be introduced into the campaign; but I, for one, should have liked to have seen an A.M.E.I.C. after his name wherever published. Those who are fellow members can profit by the reflected glory, and Mr. Public who doesn't know what the letters mean may be moved to find out—which wouldn't be such a bad thing for The Institute.

The medical practitioner never forgets the M.D. and nobody that I know of has ever accused him of conceit for carrying it around.

Very truly yours,

Herve A. Gauvin, Jr.E.I.C.

## Planning and Housing Officials

A conference of planning and housing officials is to be held in conjunction with the annual meeting of the Canadian Union of Municipalities at Ottawa, commencing on March 16th, 1937.

All those interested, including members of Town Planning Commissions and Home Improvement Associations, are cordially invited to attend.

## Recent Additions to the Library

### Proceedings, Transactions, etc.

Institution of Mechanical Engineers: Proceedings, vol. 132, 1936.

### Reports, etc.

*Governor of the Panama Canal:* Annual Report for the year ended June 30th, 1936.

*Canada, Bureau of Statistics:* Statistics of Steam Railways of Canada, 1935.

*American Institute of Mining and Metallurgical Engineers:* Year Book, January, 1937.

*Canada:* Report of the Minister of Public Works for the year ended March 31st, 1936.

*American Society for Testing Materials:* Tentative Standards 1936.

*Edison Electric Institute:* Report of the Hydraulic Power Committee on Penstocks, December 1936.

*Federal Co-ordinator of Transportation, United States:* Report of Mechanical Advisory Committee to December, 1935.

*City of Hamilton, Ontario:* Annual Report of the City Engineer for the years 1934 and 1935.

*Canada, Dept. of Mines and Resources:* Memorandum Series No. 65. Analyses of some Fuel Oils Sold in Canada.

*Montreal Light, Heat and Power Cons.:* 20th Annual Report, 1936.

*Association of Appraisal Executives:* Basic Standards of Appraisal Practice and Procedure.

### Technical Books, etc.

Canadian Almanac, 1937 (*Copp Clark Co. Ltd., Toronto*).
Federation of British Industries: Fuel Economy Review, 1936.
S.A.E. Handbook 1936.

## BULLETINS

*Nickel Products.*—A 50-page booklet has been received from Canadian Nickel Products Limited, Toronto, which contains information regarding the use of high grade nickel alloys in modern engineering developments such as hydroelectric plants, steam generation, highways, pumps, aircraft, automobiles, etc. Technical facts and data are included.

*Diesel Engines.*—Dominion Engineering Company, Montreal, has issued a 4-page leaflet containing specifications and a description of Dominion-Crossley, Types BW1 and BW2 vertical four-stroke cycle Diesel engines.

*Unit Air Conditioners.*—An 8-page bulletin issued by the Carbondale Division of the Worthington Pump and Machinery Corporation announces a new line of air conditioning units which are made in 5 models in both vertical floor and horizontal suspended types. Particulars of four models of shower condensers are also given.

*Lathes.*—Brown and Sharpe Mfg. Company, Providence, R.I., has issued a 4-page folder containing particulars and specifications of their Universal hand lathes and polishing and finishing machinery.

*Magnetic Switches.*—Two 4-page leaflets received from the Canadian General Electric Company Ltd., Toronto, describe their CR-7006 and 7008 magnetic switches full-voltage starters for induction motors.

*Glassware.*—A 4-page bulletin received from Canadian General Electric Company Ltd. describes the company's rippled street-lighting glassware.

*Cable.*—An 8-page booklet issued by the Canadian General Electric Company Ltd. contains particulars of technical installations and specifications of rubber insulated service cable from pole to and into buildings.

*Switchboard Instruments.*—The Canadian General Electric Company Ltd. have published a 12-page booklet which describes a complete line of rectangular switchboard instruments, including ammeters, voltmeters, power-factor meters, etc.

*Unit Heater.*—A 4-page folder published by the Canadian General Electric Company gives particulars of an electric unit heater for circuits of 550 volts and below; sizes of 10 kw. to 20 kw.

## Report of Mechanical Advisory Committee to the Federal Co-ordinator of Transportation

### December 27th, 1935

Two years ago the United States Federal Co-ordinator of Transportation appointed a committee of six members to advise regarding mechanical problems affecting the railroads. Under the chairmanship of L. K. Sillcox, M.E.I.C., vice-president of the New York Air Brake Company, this committee has prepared a comprehensive report which has just been issued by the Association of American Railroads, Mechanical Division.

The committee's attention was devoted to eight major topics as follows:

1. Steam locomotives.
2. Internal combustion engine locomotives.
3. Electric locomotives and electrification of steam railroads.
4. Freight train cars.
5. Rail-highway vehicles.
6. Passenger train cars.
7. Rail motor cars.
8. Streamlined trains.

The committee received and considered a great amount of documentary evidence based upon the practical experience of railroad organizations and manufacturers. Its report makes available a mass of engineering, historical and mechanical material hitherto inaccessible. To mention only a few examples, the committee has reviewed the designs of sixty-one types of steam locomotives. It has collected and discussed pertinent data regarding the present status of internal combustion locomotives. It gives up to date information regarding the various alternative methods for refrigerating freight cars. It has made a study of container service and transfer methods, and deals with the many problems involved in the adaptation of existing passenger equipment to the high speeds and new standards of comfort required in present day service.

The report is, in effect, a survey of the modern art in the construction of railroad train equipment, and throws light on the practicability of many suggested innovations and developments.

## Acoustical Terminology

A standard Acoustical Terminology for "sound" engineers which will eliminate confusion in movie, radio and building fields has just been completed, according to an announcement of the American Standards Association.

The committee gives a broader meaning to the word "noise" now defined in terms of the listener as an "unwanted" sound, rather than in terms of the sound itself. Another section of the standard deals with architectural acoustics. Other parts dealing with the conversion of sound to electrical energy, and with acoustic transmission systems, will be of particular value to the movie and radio professions.

A separate section for music brings engineers and acoustical experts into agreement with musicians on a basic standard pitch, the importance of which can be judged by the fact that an increase of only 4.14 per cent in pitch carried out through the entire keyboard of a piano would throw an additional strain of something like half a ton on the framework of the instrument.

The Association has already approved two other standards in the "sound" field. One of these, completed eight months ago, establishes "reference" and "intensity" levels for sound measurement. The other specifies the characteristics of "noise meters" used by builders, radio engineers and music teachers.

## Basic Standards of Appraisal Practice and Procedure

The reports of the Association of Appraisal Executives' Committee have been embodied in a recently issued pamphlet entitled "Basic Standards of Appraisal Practice and Procedure." This statement of principles and definitions should prove of much value to those using or relying upon appraisal reports.

The need for more generally accepted standards of appraisal practice and for greater uniformity in terminology used by appraisers has been long-recognized, and there is a demand upon the appraiser, both from business men and from regulatory bodies, for clearer definitions of the appraiser's responsibility and procedure.

Under the heading "Principles of Valuation" the pamphlet describes concepts and bases of value, and sets forth that the main goal of an appraisal is the determination of "Value for Use."

There are included about one hundred definitions of terms frequently found in appraisal reports.

The publication discusses the elements of original and historical cost, trended cost, cost of reproduction new; considers depreciation problems, and sets forth approved methods of valuation and conclusions which the members of the Association have reached through experience in appraising industries, public utilities, commercial properties and real estate.

## Erratum

In publishing a review of the Electrical Engineers' Handbook, published by John Wiley and Sons, in the January issue of The Journal, it was not made clear that the cost of these two volumes is as follows: The one on Electric Communications and Electronics $5.00, and that on Electric Power, $6.00.

# BRANCH NEWS

## Border Cities Branch

*J. F. Bridges, A.M.E.I.C., Secretary-Treasurer.*
*F. J. Ryder, Jr.E.I.C., Branch News Editor.*

After the regular monthly dinner meeting held at the Prince Edward hotel on Friday evening, December 11th, 1936, a meeting for the election of officers was held. With sixteen members present the meeting was called to order by T. H. Jenkins, A.M.E.I.C., the retiring chairman, who gave a short summary of the activities and discussions throughout the past year. The committees which had assisted him were praised for their co-operation which has made the year a very successful one.

Boyd Candlish, A.M.E.I.C., presented the Secretary-Treasurer's report, noting the improvement in the financial status of the Branch.

C. G. Armstrong, A.M.E.I.C., Branch Councillor, then gave a short synopsis of his activities at the Plenary Meeting. The points stressed were: the question of Consolidation of The Engineering Institute with the various Provincial Professional Associations, and the coming Semi-centennial of The Institute in June.

D. T. Alexander, M.E.I.C., spoke for the papers committee and was highly commended for his labours.

Owing to the absence of members there were no reports from the Membership Committee or the Educational Committee.

J. B. Clark Keith, A.M.E.I.C., and F. J. Ryder, Jr.E.I.C., were appointed scrutineers and nominations were called for the various Branch officers.

C. F. Davison, A.M.E.I.C., was elected chairman by acclamation. E. M. Krebser, A.M.E.I.C., was elected vice-chairman and J. F. Bridges, A.M.E.I.C., secretary-treasurer.

It was moved by H. J. A. Chambers, A.M.E.I.C., and seconded by F. Stevens, A.M.E.I.C., that the Councillor should bring to the attention of Headquarters the radio broadcasting that is being undertaken by the legal and medical professions and to see if something of a similar nature could not be arranged in order to inform the public of the work that is carried on by engineers. Carried unanimously.

W. H. Baltzell, M.E.I.C., who has been a member of the Branch for a long period, was presented with a gold membership badge for his services and received a hearty ovation from those present.

In the remaining time, Mr. Baltzell reviewed some of the peculiar problems which had confronted him in the past and his method of approaching the solution of them. Among the most outstanding was the manufacture of a cotton press, the design of a peculiar type cannon, furnaces built in waterproof tanks in areas subjected to floods, blast furnaces and many others. Mr. Baltzell believes that he made the first electric flash-light and battery in the United States. However it was not an invention as he merely improved on one borrowed from an English friend.

R. C. Leslie, A.M.E.I.C., who was amazed at Mr. Baltzell's memory for details as far back as 1867, moved a hearty vote of thanks with which everyone unanimously agreed.

### Drop Forgings

The Border Cities Branch held their monthly dinner meeting in the Prince Edward hotel, with twenty-three persons present. After the dinner, T. H. Jenkins, A.M.E.I.C., the chairman, introduced Mr. R. E. Waldron, chief engineer of the Dominion Forge and Stamping Company Limited, Walkerville, who delivered a paper on "Drop Forgings."

A brief historical sketch of the development of drop forging was given. Very little information is obtainable on this subject for in the early days the art of forging was kept in the family with great secrecy, and was passed on from father to son. The first known method was the use of the hand hammer to work brass and iron that had been heated. The art of smelting iron was unknown at that time. The product obtained in those days was far superior to present day attempts. Later the hand hammer was replaced by the pedal-operated hammer and then by horse-motivated power followed by the use of water and steam power. Naismith's hammer is the ancestor of the modern steam-hammer of which there are several types.

On this continent, the New England states was at first the centre of the drop-forging industry. However, with the coming of the automobile the centre of the industry moved west to the vicinity of Detroit. At present 80 per cent of all drop forgings are used by the automobile factories.

Mr. Waldron then gave examples of the operations required to forge a connecting rod and a crank shaft for an automobile, showing the form of the material after each operation with samples taken from actual production.

During each operation scaling, cleaning and oiling of the metal takes place. Usually all operations are finished with the material being given only one heat. After the piece is finished it is heat-treated, quenched and drawn.

With the aid of plaster of paris dies of the crank shaft, the speaker explained how the dies would wear down and would have to be recut. A very careful check of the finished pieces gave warning when it would be necessary to recut the dies.

Mr. Waldron received a hearty vote of thanks which was moved by Boyd Candlish, A.M.E.I.C., and endorsed by everyone.

## Halifax Branch

*R. R. Murray, A.M.E.I.C., Secretary-Treasurer.*
*C. Scrymgeour, A.M.E.I.C., Branch News Editor.*

The annual meeting of the Halifax Branch of the E.I.C. took place at the Halifax hotel on Thursday, December 17th, 1936, when there were about thirty members present.

After the election of officers, the Chairman, C. S. Bennett, A.M.E.I.C., introduced Professor H. W. McKiel M.E.I.C., of Mount Allison University and a member of the Plenary Council, who gave a particularly interesting and instructive address on the subject of the proposed consolidation or amalgamation between The Engineering Institute of Canada and the various professional Provincial bodies, as well as with other engineering societies. Professor McKiel pointed out in his opening remarks that he found a general feeling prevailed that the Council did not feel consolidation was necessary, but this impression was incorrect, as the Plenary Council did feel that consolidation was both necessary and would in time be made possible, but that the many difficulties of putting consolidation into effect, due to the varied ideas on this subject in the respective provinces, made it necessary for slow and deliberate action before a definite proposition could be submitted which would be acceptable to the engineers in Canada as a whole.

The particular drawback of the situation at present apparently, according to Professor McKiel's address, is the difficulty surrounded by Clause 7 *b* of the recommendations made by the Committee on Consolidation.

At the conclusion of the speaker's address, Harold Johnston, M.E.I.C., spoke at length outlining the expressions of opinion as generally agreed upon by the Halifax Branch, and in addition, several other speakers were heard on the same subject.

## Hamilton Branch

*A. R. Hannaford, A.M.E.I.C., Secretary-Treasurer.*
*W. W. Preston, S.E.I.C., Branch News Editor.*

### Annual Meeting

When the Hamilton Branch of The Institute held its annual dinner meeting on January 6th, 1937, in the Wentworth Arms hotel, seventy members saw how an annual meeting is made unusually interesting. The highlight of the evening was a burlesque address by Geo. E. Patton of Toronto, but other features also contributed much to the members' enjoyment. The business session which followed the dinner was as brief as possible. With W. Hollingworth, M.E.I.C., the retiring chairman, as presiding officer, A. Love, M.E.I.C., the retiring secretary-treasurer, presented his annual report, which showed a healthy financial condition and an excellent attendance at the general meetings of 1936. Mr. Hollingworth commended the retiring secretary-treasurer for the enthusiastic service which he has rendered the Branch, and pointed out that credit for the largely attended meetings was due in no small measure to the outstanding succession of speakers secured by W. J. W. Reid, A.M.E.I.C., retiring chairman of the Papers Committee. The election of officers was a simple matter, as the report of the Nominating Committee was accepted without amendment. Chairman-elect Col. E. G. MacKay, A.M.E.I.C., then took the chair. In a few well chosen words he expressed his thanks for the honour bestowed on him, and added a word of congratulation to Mr. Reid who had not only arranged a fine series of meetings for 1936 and the present meeting, but had also an announcement to make concerning the next five meetings. Two of the prominent visitors, R. L. Dobbin, M.E.I.C., of Peterborough, and Mr. Jos. Culley of the Construction Association, brought words of greeting. The guest speaker of the evening, the Toronto entertainer, Geo. E. Patton, was introduced by W. Patterson, of Brantford. Mr. Patton had as his subject "The Tropical Valley of Alaska." In a unique address with lantern slides he uncovered south sea scenery on an Alaskan sea shore in the middle of Australia. He kept his hearers in continual tears of laughter as he kept pointing out formations of bare rock which were likely to be overlooked. The lecture added to (or subtracted from) the members' knowledge of geography, geology and streamlining. Mr. Patton later gave two humorous readings. The vote of thanks was moved by E. P. Muntz, M.E.I.C.

### Acoustical Engineering

On January 14th, 1937, Mr. W. J. Hodge, acoustical engineer with Johns-Manville of New York, addressed the Hamilton Branch at McMaster University on the subject of "Acoustics and Sound Control." The attendance of 122 included several members of the Hamilton Chapter, Ontario Association of Architects, and representatives of the Hamilton Construction Association.

Sound, Mr. Hodge stated, is the father of vibration, and vibrat io the father of sound. When sound is recorded on a phonographic disc lines of vibration are inscribed thereon, and when the disc is run in a phonograph the lines of vibration produce the original sound. By means of a sound film the speaker reviewed the important principles underlying vibrations and sounds. The unit of sound measurement is the decibel which was defined as the slightest change in loudness that can be perceived by the human ear. The range of hearing is bounded by zero decibels on the sound scale and 120 decibels. Zero is the level which is just inaudible and on reaching the 100 decibel level the ear experiences lasting pain. Mr. Hodge demonstrated various sound levels using an instrument called the noise meter. He expressed the opinion that when the decibel scale is more widely known, it will be just as informative as our temperature scale.

The problems which the acoustical engineer faces are of two types. The first, which may be termed the acoustics of room interiors, deals principally with air-borne sounds. It may be a question of improving audition in a public hall, that is eliminating echoes and reverberations, and at the same time preserving clarity of tone with its many harmonics, or it may be a question of reducing a noise level as in an office. The second type of problem, which may be classed as sound isolation, treats with vibrations through materials. The engineer attempts to prevent sounds and vibrations generated in one place from reaching another through interposing material such as walls and floors. In this division comes the isolation of machine-vibrations from the building which houses the machine. Frequently both problems must be considered simultaneously.

Although the architectural design of a room has a considerable effect on sound control, the sound absorbing properties of the building materials must be carefully considered. When sound waves strike a hard surface they are readily reflected, but when they strike a porous material they become entangled in the pores and are dissipated (rather than absorbed) as heat. The thicker the material the better the absorption. However, excessive thickness will make the room too dull. Thin flexible materials also absorb sound well. Even though hard surfaces reflect sound, a perforated sheet of metal placed over a porous material is just as effective as the sound absorbing material by itself. The truth of this statement Mr. Hodge verified by demonstration.

To prevent the transfer of vibrations between adjacent bodies, all solid connections must be separated and some isolating material such as hair felt interposed. The speaker demonstrated the amount of this absorption by comparing amplified noises which resulted when he placed a small running motor on a thin concrete slab (whose vibration noises were amplified) with the noise generated when he placed the motor on an isolated platform resting on the slab.

In conclusion Mr. Hodge described a modern acoustical laboratory and answered a number of questions.

Following a vote of thanks the meeting adjourned for refreshments.

### The Oil Industry

At a joint meeting of the Hamilton Branch of The Institute and the Hamilton Chemical Association at McMaster University on January 20th, 1937, F. A. Gaby, D.Sc., M.E.I.C., Executive Vice-President of the British American Oil Company, Limited, gave an address entitled "The Engineer and Chemist in the Oil Industry." Dr. Gaby, who was introduced by J. B. Carswell, M.E.I.C., discussed the magnitude of the oil industry on this continent, its importance to the people of the world, and the place held by the engineer and chemist in bringing it to its enormous and valuable position.

The oil industry began about eighty-five years ago, though the use of oil was known for centuries; the Egyptians preserved mummies with it and built asphalt streets. In 1850 an Englishman eliminated coal oil from coal, and a few years later oil was obtained from wells in Pennsylvania. The first oil well in Canada was operated in 1858. The production from our industries reached a peak in 1924 and has since declined. Canada has had no fields of any magnitude, but it is hoped that a recent discovery on the west flank of the Turner Valley in Alberta will be exceptionally productive. The oil industry, now advanced to the place where its derivatives are counted by thousands, employs a million people and represents an investment of fourteen billion dollars.

In outlining the various problems that confront the engineer and the chemist in the oil industry, Dr. Gaby referred to the methods of finding deposits, drilling, pumping, transportation, refining and marketing. It is the engineer's task to locate pockets of oil and gas. The chief difficulty is to find suitable rock formations. When the geology of a district cannot be interpreted, the indirect methods of prospecting, such as by seismograph, are useless, and bore holes must be drilled. Drilling is an expensive operation and requires a great deal of skill. In the rotary method, which is the most popular, the problem is to direct the path of the drill at various angles through different rocks. The speaker praised the mechanical engineers for designing drills which can penetrate 13,000 feet underground without breaking under the tremendous torsional strains developed. When a drill strikes an oil pocket there may be sufficient gas pressure to drive out the oil, but frequently it must be pumped. A turbine pump, Dr. Gaby stated, on a well from 6,500 to 7,500 feet deep and having a five-inch discharge pipe, will deliver about 2,500 barrels per day. The magnitude of the transportation problem is apparent from the fact that one tenth of the total tonnage carried by the railways is for the oil industry. The early methods of refining depended largely on physical rather than chemical considerations, but it is now realized that pressure, temperature and catalytic actions are of supreme importance. The practice of oil cracking during the past twenty-three years has provided a great boom to the industry in U.S.A. Oil being lost in gas is separated by a squeezing process, but 95 per cent of the waste gas is burned because of high transportation costs. As the trend of the automotive industry is to increase speed there is an ever enlarging market for products of the oil industry. Diesel engines in ships, heavy trucks and busses, and agricultural implements also provide a field for the oil industry.

In closing, Dr. Gaby told his hearers that the oil industry had suffered long from lack of technical research, but now that engineers and chemists are adopting scientific methods to replace empirical methods, conditions are much better. He expressed the opinion that if the technical man took a greater interest in political economy and its problems, world conditions would also improve.

L. W. Glegg proposed a vote of thanks which was heartily supported.

## Montreal Branch

### Annual Meeting

The annual general meeting of the Montreal Branch of The Institute was held on January 7th, 1937, with J. B. D'Aeth, M.E.I.C., in the chair.

H. Massue, A.M.E.I.C., was elected chairman of the Branch for the year 1937, and Brian R. Perry, M.E.I.C., vice-chairman.

Business included the reception of the following reports: The Executive Committee; the Financial Statement, showing a cash surplus of $1,349.00; The Membership Committee, the total membership of the Branch is 1,181, being an increase for the year of 20 members; and the Papers and Meetings Committee.

The meeting received with sincere regret the resignation of C. K. McLeod, A.M.E.I.C., which terminates a period of twelve years of able service as Secretary-Treasurer of the Branch.

Following the meeting, moving pictures were shown and refreshments served.

### Petroleum Products

At the meeting of the Branch held on January 14th, two papers were presented: one entitled "Petroleum Products and the Automobile," by R. S. Weir, A.M.E.I.C., of Imperial Oil Limited, Montreal, and one on "Gasoline for To-day's Automobile," by Mr. G. M. Connor, of the Ethyl Gasoline Corporation, Toronto, Ontario.

### Modern Trends in Lighting

Mr. A. L. Powell, supervising engineer of the Incandescent Lamp Department, General Electric Company, New York, addressed the Branch on January 21st, his subject being "Modern Trends in Lighting."

Mr. Powell has had much to do with many outstanding lighting developments in the past two decades, and gave an exceptionally interesting talk illustrated with numerous coloured slides.

Prior to the meeting an informal dinner was held at the Windsor hotel.

R. N. Coke, A.M.E.I.C., was in the chair.

### Junior Section

At the annual meeting of the Junior Section of the Branch held on January 18th, C. E. Frost, A.M.E.I.C., was elected chairman of the Section, P. E. Savage, S.E.I.C., was elected vice-chairman, and Messrs. L. Trudel, S.E.I.C., and V. S. Upton, S.E.I.C., were elected to the Executive Committee.

At this meeting H. Massue, A.M.E.I.C., chairman of the Montreal Branch, gave a very interesting talk on "Economic Trends and Their Effect on the Employment of Engineers," in which the speaker analyzed economic trends and their lesson to the engineer.

## Niagara Peninsula Branch

*P. A. Dewey, A.M.E.I.C., Secretary-Treasurer.*
*C. G. Moon, A.M.E.I.C., Branch News Editor.*

With Chairman George H. Wood, A.M.E.I.C., presiding, the fourth dinner-meeting of the season was held at the Fox-head Inn on December 16th, 1936.

Mr. J. W. Bateman, manager of the lighting service department, Canadian General Electric Company, Toronto, had prepared a paper dealing with "A New View-point in Lighting." The subject covered newer developments in the lighting field brought out by recent research into the relationship between vision and lighting. Previous technical progress dealt largely with light sources, reflectors and the control and distribution of light, but it is now realized that seeing is a partnership of vision and lighting.

Mr. Bateman was unavoidably prevented from attending the meeting and Mr. H. C. Jones, of the same department, dealt most capably with the subject, explained the slides and answered the many questions which followed.

Mr. Graham of the A.I.E.E. spoke briefly in appreciation of the courtesies of the Branch meetings being extended to local members and Messrs Gisbourne, Buss, McKenzie and Griffiths took a prominent part in the discussion which followed the speaker's address. Councillor E. P. Murphy, A.M.E.I.C., it is understood, was attending another meeting in Montreal.

### Transmission of Speech and Music

A joint dinner meeting with the Niagara District Chemical and Industrial Association was held on January 14th, at the Leonard hotel in St. Catharines.

D. G. Geiger, A.M.E.I.C., transmission engineer with the Bell Telephone Company, was the principal speaker. His address dealt with the transmission of speech and music and, aided by a loud-speaker phonograph attachment, he was able to demonstrate effectively the variation in tone caused by the elimination of upper or lower harmonics.

An attendance of 106 filled the large dining room of the hotel, giving promise of a healthy up-swing and encouraging the officers in their endeavour to make the Niagara Peninsula noted for good meetings.

W. D. Bracken, A.M.E.I.C., introduced the speaker as an old school friend and Mr. Harold Fair, of the Chemical Association, seconded by E. P. Murphy, A.M.E.I.C., proposed the vote of thanks.

At the close of the meeting an Executive session was held to deal with various routine matters and some questions concerning "Consolidation." Clause 7 *b* was discussed and, in an endeavour to smooth out differences which threaten to wreck the whole scheme, a unanimous resolution was passed asking Council to reconsider the stand taken at the Plenary Meeting.

## Ottawa Branch

*F. C. C. Lynch, A.M.E.I.C., Secretary-Treasurer.*

The 27th annual meeting of the Ottawa Branch of The Engineering Institute of Canada was held at the Auditorium of the National Research Laboratories, Sussex Street, on the evening of January 14th, 1937. About 75 members were present, the retiring chairman, E. Viens, M.E.I.C., presiding.

The chairman's address presented a brief summary of the activities of the Branch for the year and also touched upon certain steps that had so far been taken in connection with the proposed consolidation of the profession in Canada through the facilities of The Institute in co-operation with the provincial engineering associations.

The secretary-treasurer's report revealed that the finances of the Branch were in good condition with a cash balance (including bank balance, cash on hand and government bonds) of $1,659.07, and total assets of $1,739.82. The total membership is 332 resident and 70 non-resident members. The death was recorded with deep regret of Mr. W. T. Cuffe-Quinn, Branch Affiliate.

In accordance with the motion passed at the last annual meeting the Branch donated two sets of draughting instruments to the Ottawa Technical School for presentation as prizes for proficiency in draughting. A copy of "Standard Handbook for Electrical Engineers" was sent to the Hull Technical School to be awarded to one of the students.

During the year the Managing Committee held eleven meetings for the transaction of general business. The Branch itself held eighteen luncheon meetings at which addresses were heard on engineering and allied topics. Attendance at these luncheon meetings varied from 59 to 129.

Reports of Committees presented, after the Chairman's address and the Secretary-Treasurer's report, included: Proceedings Committee by E. M. Dennis, A.M.E.I.C., Membership Committee by N. B. MacRostie, A.M.E.I.C., Advertising Committee by G. R. Turner, A.M.E.I.C., and By-laws and Reception Committee by T. A. McElhanney, A.M.E.I.C.

The report of the Aeronautical Section stated that this section held seven evening meetings at which technical papers relating to aeronautical engineering were given. The average attendance at these meetings was 28. During the year the chairman was Dr. J. J. Green, of the National Research Laboratories, and the Secretary was J. T. Dyment, S.E.I.C., of the Aeronautical Engineering Division, Department of National Defence. A small cash grant by the Ottawa Branch of The Institute is given over to this Section each year.

A vote of $25 was also passed by the Branch to take care of further awards during the forthcoming year to the Ottawa and Hull Technical Schools.

There was a lengthy discussion on certain proposals on the question of consolidation after which the branch adopted a resolution which recommended to the E.I.C. Council that steps be taken to change the name of The Institute to The Royal Engineering Institute of Canada if, as and when the consolidation of the engineering profession takes place.

After the reading and discussion of reports, together with business arising therefrom, the election of officers for the new year was announced.

The retiring chairman, E. Viens, M.E.I.C., then called upon the new chairman, J. G. Macphail, M.E.I.C., to take the chair.

G. J. Desbarats, Hon.M.E.I.C., and Dr. R. W. Boyle, M.E.I.C., moved the vote of thanks to the retiring officers. Dr. Boyle made special reference to the retirement of F. C. C. Lynch, A.M.E.I.C., who had served the Branch for more than fifteen years as secretary-treasurer.

After the business portion of the meeting was concluded, W. L. Saunders, A.M.E.I.C., of the Department of Highways, Ontario, who took part in the Vimy Pilgrimage and later visited Germany, gave an illustrated address on construction work in Germany, with particular reference to highways construction. Following his address, refreshments were served, the meeting lasting until midnight.

### Some Observations on Highway Construction in Germany

Road building machines in use in Canada and the United States are toys by comparison with the machinery being used in Germany for the construction of super-highways, stated Mr. Saunders. The work was all let on contract and conditions, he said, were an eye-opener to him. The specifications demanded were extremely high.

The men working on road construction lived in camps and had accommodation as good as in a hotel. There were even bedspreads on the cots. They were well paid and married men, working on road jobs, received extra pay as separation allowance.

Formerly there was no co-ordination in road building in Germany, Mr. Saunders said. Each province built its own roads with the result that there were roads of all kinds and widths, with numerous intersections and grade crossings. Now there is a system of super-highways under way and the entire country is under a minister of highways. Thousands of pieces of heavy machinery are being used in building these roads which are in parallel sections each 29 feet wide, each section being a one-way road

The road building programme in Germany has been going on for about three years and up to May 1936 some $350,000,000 had been spent, which provided 40,000,000 hours of work to 118,000 men. The programme provides for between 4,000 and 5,000 miles of highway and all has been located and improved, the speaker said.

The new super-highways, he added, by-pass municipalities; there are no grade crossings, and all are in new locations. All crossings are under or over and it is estimated that 10,000 bridges will be required. Pedestrians must also use bridges to cross the highways.

There is no speed limit on the one-way super-highways which were being designed for a half-century hence. In answer to those who said Germany was building the roads for purposes of war, Mr. Saunders said the country was doing a very thorough job and if the roads were to be used for war, such war was a long time off as there was still a great deal of construction ahead of the nation.

### The Greatest Menace to Canadian Forests

At the last noon luncheon of the 1936 calendar year, held at the Chateau Laurier on December 17th, the members of the Ottawa branch listened to a most interesting address upon the subject "The Greatest Menace to Canadian Forests." Dr. J. M. Swaine, director of Research of the Dominion Department of Agriculture, and former Associate Dominion Entomologist, was the speaker.

E. Viens, M.E.I.C., chairman of the Ottawa Branch, presided and in addition head table guests included: Major General A. G. L. MacNaughton, M.E.I.C., Dr. G. S. H. Barton, C. J. Booth, Dr. A. Gibson, F. C. Askwith, A.M.E.I.C., D. Roy Cameron, M.E.I.C., L. L. Bolton, M.E.I.C., T. A. McElhanney, A.M.E.I.C., T. S. Mills, M.E.I.C., F. E. Lathe, and J. McLeish, M.E.I.C.

"The total mortality caused by insect ravages in our forests is many times greater than that caused by fires," stated Dr. Swaine, "yet only a few thousand dollars a year are spent on the investigation and control of forest insect pests, whereas very large sums are spent every year towards the control of forest fires. The time has come in this country, indeed it is long since past, when the control of forest insect and fungus pests should receive the same sort of attention that is devoted to the prevention and control of fires.

"During the last thirty years or more, fires have destroyed some 70 million cords of balsam fir and spruce pulpwood," he remarked. "But during one great insect outbreak alone, more than 200 million cords of balsam fir and spruce pulpwood were killed."

Dr. Swaine referred to a few of the more important forest insect epidemics: the small four-winged larch sawfly that first came over from across the Atlantic about a hundred years ago and that did inestimable damage across the country before efforts were undertaken to fight it by the introduction of parasites, the spruce budworm which caused appalling losses in Eastern Canada in the last quarter of a century, small bark beetles of various kinds, and others.

Another sawfly, called by entomologists the European Spruce Sawfly, was noted in 1930 doing extensive injury to the spruce in the Gaspe peninsula. The Dominion Entomological Branch of the Department of Agriculture concentrated its efforts upon fighting it through the liberation of imported parasites since it appeared to be immune from attack from native parasites.

This sawfly has subsequently spread eastward across New Brunswick and into Nova Scotia, and westward across the St. Lawrence river and past lake Timiskaming into Ontario. The heavy infestation and actual mortality of the timber is still confined to the centre of the Gaspe peninsula, where the injury has been very heavy, but how rapidly the light infestations will develop into the destructive stage no one can yet foretell, remarked Dr. Swaine.

With regard to the most valuable stands aeroplane dusting with poisonous dusts may sometimes be used, but this costs money. With the spruce pest the cost is from $3 to $6 an acre, and the operation, due to the life habits of the sawfly, would need to be repeated for at least several successive seasons. No other direct method of control could be effective.

The entomologists therefore hope to control this epidemic with the importation of the sawfly's native parasites from their original home in Europe. Over there, parasites have succeeded in keeping it well under control.

Millions of these parasites have been collected in Europe and shipped to the Parasite Laboratory of the Entomological Branch at Belleville, Ontario, from which place, after being multiplied to enormous numbers, they are eventually liberated in many parts of the infested forest.

Dr. Swaine closed his address with the statement that only through co-operative effort on the part of all those interested could a task be accomplished so great as policing the forests of eastern Canada and reporting and investigating infestations in their initial stages, when effective control measures can be applied with any hope of success. "We are hopeful that," he concluded, "before much longer, forest protection in Canada will include protection from insect pests and fungus diseases as well as protection from fires."

## Saskatchewan Branch

*J. J. White, M.E.I.C., Secretary-Treasurer.*

The regular monthly meeting of the Saskatchewan Branch of The Engineering Institute was held in the LaSalle hotel, Regina, on December 18th, 1936, with an attendance of thirty-one members and guests. Stewart Young, M.E.I.C., vice-chairman of the Branch, was in the chair.

Mr. Young requested Mr. Junius Jonsson, city engineer of Prince Albert, to say a few words on behalf of the visitors present.

At the conclusion of the business portion of the meeting, the members enjoyed a very interesting and instructive address by Mr. W. H. Ross, superintendent for Dominion Electric Power Limited, on "Diesel Engines and Their Operation," particularly with respect to cylinder heads and common causes of failure in standard type heads. Mr. Ross went on to describe a new type 2-cycle Diesel cylinder head of his own design which he has recently had patented and of which he now has five operating in a very successful manner and with considerable saving in fuel.

The meeting closed with a lengthy and animated question period during which Mr. Ross answered a great number of questions very much to the interest and satisfaction of his questioners, after which a hearty vote of thanks to the speaker was moved by H. S. Carpenter, M.E.I.C., and seconded by J. W. D. Farrell, M.E.I.C., with the hearty applause of those present.

## Winnipeg Branch

*H. L. Briggs, A.M.E.I.C., Secretary-Treasurer.*

### Shelling of Tires

At the meeting of the Branch held on January 7th, 1937, the speaker was Mr. James Gilchrist, chief inspector of materials, Canadian National Railways Western Region. The shelling of tires is the flaking and flatting of steel tires in railway service, and takes place most frequently during severely cold weather such as is experienced at times in Western Canada. After the beginning of the Great War, when Krupp tires could no longer be purchased, the shelling out of tires on locomotives, coaches and other rolling stock became very serious. The shelled tire nicks the rails, and the wheels which follow break the rails. As many as 20 miles of rails have been broken in one night by a shelled tire.

The difficulty can be overcome by the proper heat treatment of the tire before it is placed. If a very fine crystalline structure is produced in the metal of the tire, it will not shell out. The cause of the shelling out is a pulling apart of the metal itself, under the condition of the surface of the tire being heated due to rolling on the rail, while the main body of the tire is very cold due to the low temperature.

D. L. McLean, A.M.E.I.C., moved a hearty vote of thanks to the speaker.

Prior to the main paper, A. J. Taunton, M.E.I.C., presented number 4 of the "I Remember" series, speaking on his early experiences in engineering work in Western Canada.

The chair was occupied by G. E. Cole, A.M.E.I.C.

## The Leipzig Fair

A recent announcement emanating from the President of the Leipzig Fair Administration states that the Engineering Exhibition next Spring will be four times as extensive as that of the year 1932, and is expected to exceed that of 1936 by about 15 per cent. The new arrangements, which will be followed in future, provide for the removal of the International Trade Exhibition into the town, and the concentration of the various branches will require separate halls for the Office Requisites Industry and for the Textile, Laundry and Sewing Machines Industry. In order to provide the required accommodation, it will be necessary to build new halls, and as these will not be ready in time for the next Spring Fair a large marquee is being erected as a temporary measure.

The Samples Fair in the inner town has also been considerably enlarged, mainly as a result of the exhibitions of raw materials. Transportation arrangements for overseas visitors to the Fair will be greatly improved and airship traffic will materially reduce the time taken in travelling.

In connection with this Fair, a tour of Canadian and American business men is being arranged, which will start on February 20th via the liner *Bremen* and provide for the return on the *Hansa*, arriving in New York on March 26th. The trip will also include visits to several industrial centres in Germany, and an opportunity to inspect a number of large industrial plants. Information in this connection may be secured from Mr. L. Mueller-Hickler, honorary representative, Leipzig Trade Fairs, 1178 Phillips Place, Montreal.

## Hydro-electric Progress in Canada in 1936

The annual review of hydro-electric progress in Canada prepared by the Dominion Water and Power Bureau, Department of Mines and Resources discloses that, although a comparatively small addition was made to the total developed water-power capacity in the Dominion during 1936, there are a number of developments actively under construction which will add materially to the total in the next year or more. New installations during 1936 aggregated 36,475 h.p., bringing the total for the Dominion at the end of the year to a figure of 7,945,590 h.p.

The programme of hydro-electric development throughout Canada during the past few years has been largely influenced by conditions brought about by the recession period 1930 to 1933. In the month of May of that year the demand again turned upward and has continued to do so month by month to the present time. Notwithstanding conditions in the years of recession much construction, being well started, had to be proceeded with and gradually brought to completion, thus providing a generating capacity in excess of existing power demand and rendering unnecessary for the time being the initiation of new projects. The spread between installed capacity and power output has been rapidly narrowing in the past three years.

In this connection the monthly figures of output of central electric stations compiled and published by the Dominion Bureau of Statistics are of special significance.

The principal activities in hydro-electric development in the various provinces are described hereunder.

### British Columbia

New water-power installations in British Columbia were four in number. Quesnel Light and Power Company completed a 200-h.p. hydro-electric plant on Baker creek near Quesnel. Hope Utilities Limited installed a 50-h.p. plant on Schkam creek near Hope which is now supplying power to that village. The Canadian National Railways installed a 100-h.p. plant on Stoyoma creek to supply electrical energy to the railway shops and premises at Boston Bar. The Ashloo Gold Mining Company has installed a 75-h.p. Pelton wheel for the purpose of supplying compressed air for mining purposes.

A number of other installations are under consideration. The Vancouver Island Power Company proposes to supplement its power supply by a 1,953-h.p. installation on Loss creek. The Consolidated Mining and Smelting Company is, through its subsidiary the Buena Vista Mining Company, installing two 1,500-h.p. wheels on Cascade creek for the purpose of supplying Big Missouri Mine.

### Alberta, Saskatchewan and Manitoba

No new power development was undertaken in Alberta during the year but in Saskatchewan the Churchill River Power Company is installing an additional 19,500-h.p. unit at its Island Falls plant for which concrete work and the power house extension is about completed. It is expected that the new unit will be placed in operation about midway through 1937. In Manitoba the city of Winnipeg has commenced the installation of a third unit, 12,500 h.p., at its Slave Falls development on the Winnipeg river which, it is expected, will be ready for operation next autumn.

The Manitoba Power Commission added 133 miles to its transmission system and erected a number of new substations during 1936.

### Ontario

In Ontario, development was confined to the northwestern section of the province. The Hydro-Electric Power Commission of Ontario which completed the construction of and operates the Canyon (Abitibi river), and constructed and operates Ear Falls (English river) and Rat Rapids (Albany river) stations as trustee for the Provincial Government brought a new unit of 1,750 h.p. into operation in the Rat Rapids station early in October and is proceeding with construction to provide for the installation of a second unit of 5,000 h.p. in the Ear Falls station during the coming year.

The Commission acquired by purchase during the year three plants on the Trent Canal System at and near Lakefield. These three plants have a combined capacity of 4,200 h.p. and will be operated to augment the power supply of the Commission's Eastern Ontario System.

Consideration was also given by the Commission to the development of a 10,000-h.p. site at Ragged Rapids on the Musquash river to augment the supply of power to its Georgian Bay System and also to further development on the Madawaska river for its Eastern Ontario System.

The Great Lakes Power Company has constructed a dam and power house on the Montreal river which will be interconnected with its other plants at Sault Ste. Marie and Michipicoten Falls. The initial installation is 10,000 h.p. and is expected to be in operation early in 1937.

### Quebec

The only additional installation in the province was that of a fourth 30,000-h.p. unit at the Maclaren-Quebec Power Company's hydro-electric plant on Lievre river at High Falls, bringing this development up to its full capacity of 120,000 h.p.

Power developments now under construction include the Ontario Paper Company's 66,000-h.p. hydro-electric plant on Outardes river at Outardes Falls where the dams and intake have been practically completed; the penstock and pipe line foundations have been well advanced; the power house substructure and the super-structure steel as well as the tailrace are almost completed, while work has been started on the transmission line to Baie Comeau, 10 miles distant.

The city of Sherbrooke has started preliminary work on a 7,000-h.p. development at Two-Mile Falls on the St. Francis river.

The Beauharnois Light, Heat and Power Company has not increased its installed capacity of eight 50,000-h.p. units but made the necessary changes to operate another of its units at 60 cycles so that it has now four units furnishing 60-cycle and four units 25-cycle power.

The Mont Laurier Electric Company has started work on replacing its present 200-h.p. installation with a 500-h.p. unit.

The town of Magog contemplates a $400,000 hydro-electric development on Salmon river near Kingsbury.

Short additions have been made to transmission lines in various parts of the province while substantial extensions of distribution systems are also to be noted.

### New Brunswick

No new hydro-electric installations were undertaken in New Brunswick during the year but the New Brunswick Electric Power Commission completed the new 6,250-kilowatt turbo-generator additions to its fuel-power station at Newcastle creek.

In addition to the above the Commission has completed and placed in operation about 190 miles of 6,600-volt transmission lines.

### Nova Scotia

In Nova Scotia, the Nova Scotia Power Commission has completed the 4,300-h.p. addition to its Ruth Falls plant on East River Sheet Harbour, installed a new 24-h.p Diesel plant at St. Peters, Cape Breton.

There are now under construction a 2,500-h.p. development at Salmon Hole on the St. Croix river by the Minas Basin Pulp and Power Company and a 3,750-h.p. development on Paradise Brook by the Annapolis Power and Paper Company, whilst a 5,200-h.p. development is projected by the Nova Scotia Power Commission at Lower Great Brook on the Mersey river to supply increasing power demands of the Mersey Paper Company.

There has been a considerable amount of transmission line extension during the year; those of the Nova Scotia Power Commission aggregated about 6 miles whilst those of the Nova Scotia Light and Power Company and its subsidiaries total between 60 and 65 miles.

## List of New and Revised British Standard Specifications

(Issued during December, 1936)

B.S.S. No.

417—1936. *Galvanized Mild Steel Cisterns, Tanks and Cylinders.* (Revision.)
The revised specification provides for an increased range of sizes for cisterns, tanks and cylinders. Requirements are included for the methods by which the larger sizes should be stayed. A further modification in the revision is the permission to use welded construction.

688—1936. *Bituminous Filling Compounds for Electrical Apparatus (excluding those used for Cable Boxes)*
Applies to fluid, plastic and hard bituminous compounds suitable for use as filling compounds which are subjected to electrical stress in service in electrical apparatus other than cable boxes.

699—1936. *Copper Cylinders for Domestic Purposes (Grades 1, 2 and 3).*
Specifies the quality of the material, the method of workmanship and the sizes of cylinders. It provides for three grades differentiated by the thickness of the copper sheet used in the construction, which in consequence limits the working head with which they can be used.

717—1936. *"Combustion Testing" of Domestic Gas Appliances.*
Describes standard methods for the "combustion testing" of gas fired cooking appliances for water heaters and fires.

718—1936. *Density Hydrometers.*
A specification for Hydrometers to indicate density—mass per unit volume—in grammes per ml. at 20 degrees C.

Copies of these specifications may be obtained from the Publications Department, British Standards Institution, 28 Victoria Street, London, S.W.1, and from the Canadian Engineering Standards Association, 79 Sussex Street, Ottawa, Ont.

## Empire Exhibition, 1938

The Guarantee Fund in connection with the Empire Exhibition which is to be held in Glasgow, Scotland, in the spring of 1938, is rapidly approaching the £600,000 mark. Preliminary plans regarding the layout of the site have been drawn up and work is expected to begin early this year.

Applications for space have already been received from many firms, not only in the United Kingdom, but in various parts of the Empire.—*Industrial Britain.*

# Preliminary Notice

## of Applications for Admission and for Transfer

January 25th, 1937

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

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The Council will consider the applications herein described in March, 1937.

R. J. Durley, Secretary.

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•The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years inthe case of a candid ate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of,age, and shall have been engaged in some branch of engineering for at least six years which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch ofengineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more year.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equiva ent standard.

**A Student** beshall at least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

**The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.**

### FOR ADMISSION

ANVIK—HERLAUG, of Temiskaming, Que., Born at Telemark, Norway, Oct. 5th, 1892; Educ., 1911-15, Kristiana Technical College. Diploma in mech. engrg.; 1915-17, dftsman., Kvaerner Brug, Oslo, Norway; 1917-18, dftsman., Union Co., Oslo, Norway; 1918-20, mill engr., Bosnische Electricitaets A.G., Innsbruck, Austria; 1920 to date, efficiency engr., Canadian International Paper Co., Kipawa and Hawkesbury, Ont.

References: C. B. Thorne, J. G. Hall, W. S. Kipp, J. L. E Price, W. G. C. Gliddon.

ASKWITH—WINSTON M., of 222 Powell Ave., Ottawa, Ont., Born at Ottawa, May 28th, 1911; Educ., B.Eng., McGill Univ., 1936; Summer work: 1928, rodman, Gatineau Power Co.; 1929-30, engr's. asst., N. B. MacRostie, A.M.E.I.C.; 1932, water service location, City of Ottawa; 1931, rodman, Ottawa Suburban Roads Commn.; 1934, engr's asst., Ont. Dept. of Highways; 1934-35, chemical analysis asst., to Dr. J. S. G. Shotwell; 1936 to date, instr'man. and asst. engr. with Federal District Commission, Ottawa, Ont.

References: A. K. Hay, F. C. Askwith, L. M. Hunter, W. M. Johnstone, N. B. MacRostie, H. R. Cram, C. D. Wight.

BRADFORD—GEORGE ALLEN McCLEAN, of 114 Cameron St., Sarnia, Ont., Born at Brockville, Ont., May 29th, 1908; Educ., B.Sc. (Mech.), Univ. of Sask., 1932; 1927-30 (summers), with constrn. party, Geodetic Survey of Canada, last two years in charge of party; Jan. 1933 to date, dftsman., Imperial Oil Ltd., Sarnia, Ont.

References: W. M. Dennis, C. J. Mackenzie, A. R. Greig, I. M. Fraser, E. K. Phillips.

CROSSE—CLAUDE ST. CYR, of Niagara Falls South, Ont., Born at London, England, Feb. 22nd, 1894; Educ., 1913-16, Calgary and Edmonton Technical Schools. Private study of engrg. subjects during the past 18 years; 1917-18, with Royal Air Force, overhauling, tuning and inspection of aero engines, and School of Aerial Gunnery; 1918-26, meter and testing lab., H.E.P.C. of Ont., Niagara Falls, Ont., gen. elect'l. tests, meter and relay calibrations; 1926 to date, Toronto power generating and transformer stations, H.E.P.C. of Ontario, gen. engrg. pertaining to plant operation and mtce., elect'l. tests and dfting.

References: A. W. F. McQueen, W. Jackson, L. L. Gisborne, B. Candlish, H. L. Bucke, H. M. King, G. E. Griffiths, G. C. Mountford, G. H. Wood, M. F. Ker.

DORAIS—GABRIEL, of 3659 Northcliffe Ave., Montreal, Que., Born at Sherbrooke, Que., Oct. 11th, 1913; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1935; 1931-32 (summers), road dept., Prov. of Quebec; 1933-34 (summers), Quebec Streams Commission; 1935-36, res. engr., road dept., on Mont Laurier-Senneterre highway; 1936-37, computor and asst. office engr., at Baie Comeau for the Ontario Paper Co. townsite office; at present, chief of a surveying party for E. Gohier, M.E.I.C., Consltg. Engr., Montreal, Que.

References: A. Mailhiot, A. Frigon, E. Gohier, A. Paradis, P. G. Gauthier.

ENGLER—CHARLES ROY, of 145 Powell Avenue, Ottawa, Ont., Born at Ottawa, July 1st, 1907; Educ., B.Sc., Queen's Univ., 1934; 1935 (Jan.-Dec.), press operator, and from July, on staff of standards dept., Beatty Bros.; Dec. 1935 to date, designer and dftsman, J. H. Connor & Son Ltd., Ottawa, Ont.

References: R. A. Low, L. T. Rutledge, L. M. Arkley, G. B. Dodge, S. D. Fawcett.

FRY—FREDERICK GEORGE, of 780 Quebec St., London, Ont., Born at London, England, Nov. 16th, 1908; Educ., B.A.Sc., Univ. of Toronto, 1933; 1927-31, shop asst. and clerk, Toronto Hydro Electric System; 1935 to date, asst. divnl. engr., Shell Oil Co. of Canada Ltd., London, Ont.

References: T. R. Loudon, W. J. Smither, J. R. Cockburn, C. R. Young, D. S. Scrymgeour.

GRAHAM—GEORGE, of 193 Waverly St., Ottawa, Ont., Born at Winnipeg, Man., Feb. 7th, 1907; Educ., B.Sc. (Civil), Univ. of Sask., 1933; 1924-26 (summers), chainman and rodman on municipal work; Summers 1927 to 1931, worked for city engr. of Saskatoon, inspr. in chief of semi-Macadam pavement constrn., also concrete sidewalk and paving and sedimentation basins; i/c concrete lane paving, also earthwork on river bank; inspr. on sewer and water constrn.; 1935 (June-Nov.), i/c field party, Dept. of Mines, investigating ground water resources of the Prairie Provinces; June 1936 to date, writing reports by municipalities on ground water resources of the same area.

References: R. A. Spencer, E. K. Phillips, C. J. Mackenzie, J. J. White, W. E. Lovell, F. C. C. Lynch.

FOTHERINGHAM—WILLIAM WEBSTER, of Edmonton, Alta., Born at Winnipeg, Man., Mar. 4th, 1911; Educ., B.Sc. (Civil), Univ. of Man., 1933; 1935-36, constrn. and shop work, also shop inspr., Manitoba Bridge and Iron Works, Winnipeg; 1936 to date, engr., Standard Iron Works, Ltd., Edmonton, Alta.

References: R. M. Dingwall, A. E. Macdonald, J. N. Finlayson, G. H. Herriot, F. V. Seibert.

SHAW—WILLIAM ULRIC, of 220 Labonte Ave., Longueuil, Que., Born at Springfield, Ont., June 1st, 1902; Educ., B.A.Sc., Univ. of Toronto, 1925; 1922-25 (summers), tracer, machinist's helper, shop work, and electrn's. helper; 1925-27, steam distribution operator, central heating dept., Detroit Edison Co., Detroit, Mich.; 1927-30, junior engr., detail design, layout, stress analysis, performance calculation, Buhl Aircraft Co., Marysville, Mich.; 1930-32, asst. engr., aeronautical engrg. dept., Dept. of National Defence, Ottawa; 1933 to date, asst. engr., Fairchild Aircraft Ltd., Longueuil, i/c structural analysis of aircraft, skis, floats and related aircraft components. Performance, estimation and deduction, detail and design of components, etc.

References: E. W. Stedman, A. Ferrier, J. H. Parkin, H. Miller, T. R. Loudon.

SOMMERVILLE—DONALD BARTON, of 131 DeForest Rd., Toronto, Ont., Born at Toronto, Ont., Jan. 7th, 1914; Educ., B.A.Sc., Univ. of Toronto, 1935; 1935 (field season), instr'man., Geol. Survey of Canada; 1936 (winter), dftsman., Dept. National Defence; Spring 1936 to date, structural engr., Canadian Comstock Co., Toronto, Ont.

References: C. R. Young, W. J. Smither, J. R. Cockburn, T. R. Loudon, C. F. Morrison.

STEIN—MARCUS, of 3849 St. Urbain St., Montreal, Que., Born at Montreal, Apri 10th, 1912; Educ., B.Eng., McGill Univ., 1934; Summer work: 1930-31-33, laborer, underground elect'l. conduits, also rodman and laborer, Montreal water intake, Ville LaSalle; 1935-37, field engr., Mont Laurier-Senneterre highway.

References: E. Brown, R. DeL. French, H. R. Montgomery, R. E. Jamieson, A. S. Dawes, C. H. Gordon.

WATSON—ALEXANDER, of 3522 Sherbrooke Street East, Montreal, Que., Born at Whitehills, Banffshire, Scotland, Feb. 21st, 1894; Educ., Robert Gordon's College (Marine Branch), Aberdeen, and Skerry's Schools, Glasgow, 1919. Extra 1st Class British Board of Trade Cert. of Competency in Marine Engrg. Elected Member of the Inst. of Marine Engrs., London, 1922; 1911-16, ap'tice engr., Watson Bros., Banff, Scotland; 1916-17, journeyman improver; 1917, with Lyle Shipping Co.

of Glasgow, as 4th engr. in full charge of watch at sea. 1918-19, above as 3rd engr.; 1920-22, with Can. Govt. Merchant Marine as 2nd engr.; 1923-26, asst. to the supt. engr., Can. Govt. Merchant Marine, Montreal; 1926-27, engrg. supt., Prince Rupert Dry Dock and Shipyard, B.C.; 1927-28, asst. supt. engr. at Vancouver, Can. Govt. Merchant Marine and Can. National Steamships; 1928-29, marine drawing office, i/c engrg. work for marine dept., Canadian Vickers Ltd., Montreal; 1929 to date, chief engr., marine dept., for same company.

References: R. C. Flitton, R. Ramsay, I. J. Tait, F. S. B. Heward, J. A. H. Henderson.

WILSON—WILLIAM BOWMAN, of Trenton, Ont., Born at Buckingham, Que., Mar. 25th, 1889; Educ., B.Sc., McGill Univ., 1913; 1910 and 1912 (summers), asst. to inspecting engr., Dept. Interior, Ottawa; 1913-16, asst. to res. engr., during constrn. of Connaught Rifle Range, Ottawa; 1927-29, res. engr., constrn. of Ottawa Air Station, and 1929 to date, constrn. of R.C.A.F. Station, Trenton, Ont.

References: E. J. C. Schmidlin, D. Barry, D. C. M. Hume, J. J. Macnab, G. M. Pitts.

### FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

DINGWALL—ROBERT MACFARLANE, of 10224-131st St., Edmonton, Alta., Born at Glasgow, Scotland, Mar. 16th, 1890; Educ., Associate, Royal Technical College, 1914, R.P.E. Alta.; 1906-11, ap'ticeship as mech. engr., A. & J. Inglis Ltd., and London and Glasgow Shipbldg. and Engrg. Co. Ltd., Glasgow; 1911 and 1913 (vacations), asst. foreman with latter company; 1914-19, overseas service. 1915, Comm'd. Officer, British Army. 1917, transferred to Royal Engrs., District Technical Office, Eawy District, France, until 1919; 1919, master mechanic, Drumheller; 1919-20, master mechanic, Mountain Park; 1921-26, head of mech. engrg. dept., Provincial Technical Institute, Calgary; 1926-28, engrg. sales mgr., Riverside Iron Works Ltd., Calgary; 1929 to date, manager and director, Standard Iron Works Ltd., Edmonton, Alta. (*A.M. 1923.*)

References: W. J. Dick, R. J. Gibb, R. W. Ross, C. E. Garnett, J. Garrett.

KEAN—DAVID JACQUES, of Whitby, Ont., Born at Cambridge, Ont., April 1st, 1884; Educ., Diploma course, S.P.S., Univ. of Toronto, 1906-1909; 1906, Ontario land survey; 1909, Ontario survey and mining claims, Nor. Ontario; 1909-10, location and constrn., C.N.R. and C.P.R.; 1911-13, Dom. Land Survey, Foothills, Alta.; 1912-13, res. engr., C.N.R.; 1913, Dom. Land survey, Peace River; 1919 to date, county road supt. and county engr., County of Ontario, including bridge design and road constrn. (*A.M. 1920.*)

References: A. E. Jupp, H. T. Routly, J. A. P. Marshall, H. A. Lumsden.

TALMAN—STEPHEN GOLDWYER, of 88 Delaware Ave., Toronto, Ont., Born at Broadstairs, Kent, England, Dec. 20th, 1875; I.C.S. Engrg. Diploma, 1910. Toronto Tech. School Surveying Diploma, 1915; 1890-92, pupil, Clay Inman Forge Co., Birkenhead; 1892-95, ap'tice, W. H. Ross & Co., Liverpool, "Scottish Isles"; 1895-97, 3rd Mate, "Scottish Isles"; 1897-98, 3rd and 2nd Officer, S.S. "Pondo"; 1898-1899, Auxiliary 2nd Officer, S.S. "Fort Salisbury"; 1900-01, South African War. Brabants' Horse; 1901-02, laying out forest reservation and road making, Cape Colony; 1902-04, asst. to Kidley & Barrie, contractors, Beira; 1904-05, river control work, Cape Colony; 1905-06, renewal of pier and tracks, Laurenco Marques Wharf Co., S.E. Africa; 1907-12, engrg. staff, DeBeers Cons Mines; 1913-17, instr'man., Dept. of Works, Toronto; 1918-19, designing, Imperial Munitions Board; 1919-20, design of plant for Salts and Potash Co. of Canada Ltd.; 1920-21, designing, Dominion Tire Co., Kitchener, Ont.; 1921 to date, with the City of Toronto as follows: 1921-22, alterations to asphalt plant; 1922-24, rly and bridge section, inspr. in charge of boring, field engr. and dftsman.; 1924-33, sewer section, dftsman.; 1933 to date, in charge of design and dfting. at water distribution machine shop. (*A.M. 1914.*)

References: G. G. Powell, J. H. Parkin, W. E. Bonn, M. A. Stewart, G. G. Routledge.

TURNER—EARLE O., of Alexander St., Fredericton, N.B., Born at Harvard, Mass., May 19th, 1893; Educ., S.B. in Civil Engrg., Mass. Inst. Tech., 1914; 1914-15, instr'man.; 1915-16, res. engr., Mass. Highway Commn.; 1916-17, instructor of highway engrg., Polytechnic Institute of Brooklyn; 1917-18, 2nd Lieut., Air Service, U.S. Army; 1919 to date, professor of civil engrg., University of New Brunswick, Fredericton, N.B. (*A.M. 1920.*)

References: P. L. Pratley, J. Stephens, A. F. Baird, A. Gray, G. Stead

### FOR TRANSFER FROM THE CLASS OF JUNIOR

ELLIOT—DONALD GEORGE, of Grand Falls, Nfld., Born at Darjeeling, India, Oct. 14th, 1909; Educ., B.Sc. (Civil), Univ. of Edinburgh, 1930; Assoc.M. Inst.C.E.; 1930-32, with Monsarrat & Pratley, Consltg. Engrs., Montreal, and 1932-34, asst. engr. with same firm, steel and concrete design, estimating and dfting.; 1934 (May-Oct.), asst. supervising engr. during constrn. of foundation piers, Ile d'Orleans bridge; 1935-36, designing dftsman., and June 1936 to date, asst. mill engr., Anglo-Newfoundland Development Co. Ltd., Grand Falls, Nfld. (*Jr. 1934.*)

References: P. L. Pratley, C. N. Monsarrat, F. M. Pratt, H. S. Windeler, J. W. Roland, S. R. Banks, R. F. Legget.

GAUVIN—HERVE ALFRED, L'Assomption, Que., Born at Lewiston, Maine, U.S.A., Nov. 7th, 1900; Educ., B.Sc. (Arts), Univ. of Sask., 1922. B.Sc. (Civil), McGill Univ., 1926; 1916-22 (summers), constrn. and operation cold storages for Sask. Co-operative Creameries: 1922-23, dftsman., Ottawa Car Mfg. Co.; 1922-26 (summers), i/c insulating crews, Capital Contractors, Ltd., Ottawa: 1926-29, chief engr. and sec. treas., Gauvin Ltd., contractors, Ottawa; 1929-33, chief engr., Gem Stone Ltd., Montreal; 1931-33, partner, Crepeau, Gauvin & Scanlan, reinforced concrete design; 1933-34 appraisals and factory layouts, World Devices Ltd., Montreal; 1934-35, asst. divnl. engr., and 1935 to date, divnl. engr., Prov. Dept. of Highways, L'Assomption, Que. (*St. 1925, Jr. 1928.*)

References: N. B. MacRostie, L. J. Leroux, G. J. Papineau, A. Paradis, J. O. Montreuil.

MIALL—EDWARD, Jr., of 407 Elgin St., Ottawa, Ont., Born at Vancouver, B.C., Dec. 5th, 1909; Educ., Grad., R.M.C., 1930; Summers 1927 to 1931, rodman, and chainman, military surveys, Dept. of National Defence, and timekpr. and sub-foreman, Rayner Constrn. Co. Ltd.; 1933-35, sub-foreman, Dept. National Defence, Project 40; 1935 to date, engr., Dept. of National Defence, Ottawa. Compilation of final administrative report and financial analysis in connection with unemployment relief projects. (*Jr. 1934.*)

References: E. J. C. Schmidlin, G. R. Turner, J. L. H. Bogart, N. Malloch, L. F. Grant, G. W. Rayner, T. V. Anderson.

MOFFAT—ALEXANDER ROBERTSON, of Bourlamaque, Que., Born at Pembroke, Ont., May 13th, 1901; Educ., 1922, one year science, Queen's Univ.; 1922-25, topog'r. and instr'man., rly. constrn.; 1925-26, transitman on rly. location; 1926-27, land and mining claims (surveys); 1928-29, transitman and dftsman, topog'l. for G. P. Angus, O.L.S.; 1929, prelim. topog'l. and precise surveys at Abitibi Canyon, Abitibi Power and Paper Co., Iroquois Falls, Ont.; 1929-30, transitman on rly. location and res. engr., T. & N.O. Rly., North Bay, Ont.; 1930-32, i/c rly. constrn., precise surveys, trans. lines, Ontario Power Service Corpn., Fraserdale, Ont.; 1932-33, topog'l. and contour surveys, reports on stream flow and other hydro data, for Teck Hughes Gold Mines Ltd., Kirkland Lake, Ont.; 1933 to date, chief surveyor of underground workings, Lamaque Gold Mines Ltd., Bourlamaque, Que. (*Jr. 1925.*)

References: W. B. Crombie, K. G. Ross, S. B. Clement, W. J. Bishop, J. M. Gilchrist, E. J. Bolger, P. C. Kirkpatrick, N. Malloch, W. L. Cassels.

REEVELY—FREDERICK RICHARD, of 20 Salisbury Rd., Pointe Claire, Que., Born at Bolton, Ont., May 28th, 1906; Educ., B.A., Univ. of Toronto, 1929; 1928, summer field party, Old Colony Mines, Millertown, Nfld.; 1929 (4 mos.), shop student course, and from 1929 to date, engr., technical development divn., Northern Electric Co. Ltd., Montreal, Que. (*Jr. 1932.*)

References: J. S. Cameron, W. H. Eastlake, N. L. Morgan, H. Miller, E. Baty.

WARDLEWORTH—THEOPHILUS HATTON, of 168 Cote St. Antoine Rd., Westmount, Que., Born at New Brighton, Cheshire, England, June 7th, 1903; Educ., B.Sc., McGill Univ., 1925; 1925-30, with Fraser Brace Engrg. Co. Ltd. as follows: estimator on hydro electric developments in Montreal office; 1926-27, rodman on rly. tunnel constrn. in South America; 1927-28, instr'man. and asst. on same job; surveys for underground and surface work, also survey and layout for hydro electric development; 1928-29, estimator in Montreal office; 1929-30, instr'man. on constrn. of copper refinery for Ontario Refinery Co. Ltd., Copper Cliff, Ont.; on surveys, layout and inspection for bldgs. and machy.; 1931-32, instr'man. and asst. engr. on constrn. of Masson hydro electric development, for James Maclaren Co., Masson, Que.; asst. on design and constrn. in connection with factory alterations, National Drug & Chemical Co. of Canada Ltd., Montreal, and Sept. 1935 to date, designer for the Aerocrete Construction Co. Ltd., Montreal. (*St. 1923, Jr. 1931.*)

References: J. B. D'Aeth, E. Brown, E. A. Ryan, E. V. Gage, E. R. Smallhorn.

### FOR TRANSFER FROM THE CLASS OF STUDENT

CAMERON—JOHN, of 574 Douglas Ave., Peterborough, Ont., Born at Antigonish, N.S., Sept. 20th, 1902; Educ., B.Sc., N.S. Tech. Coll., 1927; 1927 to date, asst. engr., industrial control engrg., Canadian General Electric Co. Ltd., Peterborough, Ont. (*St. 1927.*)

References: L. DeW. Magie, V. S. Foster, E. R. Shirley, A. B. Gates, H. R. Sills, A. L. Dickieson, T. E. Gilchrist, B. Ottewell.

DAVIDSON—ARTHUR CAMPBELL, of 1732-11th St. West, Calgary, Alta., Born at Calgary, Alta., July 21st, 1914; Educ., B.Sc. (Civil), 1935, B.Sc. (Elec.), 1936, Univ. of Man.; 1932-35 (summers), office asst., Columbia Valley Irrigated Fruit Lands Ltd., Invermere, B.C.; 1936 (June-Sept.), laborer, bridge and bldg. dept., C.P.R.; at present, studying at Univ. of Man. towards D.L.S. prelim. exams. (*St. 1935.*)

References: E. P. Fetherstonhaugh, J. N. Finlayson, A. E. Macdonald, G. H. Herriot, N. M. Hall.

EMERY—DONALD JOSEPH, of 120 Morrow St., Peterborough, Ont., Born at London, England, Feb. 24th, 1903; Educ., B.A.Sc., Univ. of B.C., 1929; 1922-23, electrician's helper; 1923-24, wiring inspr. (automatic telephones), Western Electric Co., Seattle; 1924-26, electrician, Britannia Mining and Smelting Co., B.C.; 1927, asst. elect'l. foreman (underground), with same company; 1929-30, students test course, 1930-31, junior engr., induction motor design, and 1931 to date, asst. to engr. in charge of fractional horsepower motor design, Can. Gen. Elec. Co. Ltd., Peterborough, Ont. (*St. 1927.*)

References: R. L. Dobbin, A. B. Gates, L. DeW. Magie, V. S. Foster, A. L. Dickieson, W. M. Cruthers.

DOUGLAS—ARNOLD HOWARD, of Langham, Sask., Born at Fleming, Sask., Feb. 6th, 1909; Educ., B.Eng. (Civil), Univ. of Sask., 1931; 1926-27, rodman, dept. of highways, Sask.; 1928, instr'man on land surveys; 1929, inspr. on bldg. constrn.; 1930, i/c party on drainage work; 1932, engr. i/c constrn. of Broadway Bridge, Saskatoon; 1933, engr. in charge of constrn. for R. J. Arrand, Contractor; 1934-35, engr. i/c bldg. constrn., Project 44, Dundurn, Sask.; at present, junior asst. engr., Dept. Public Works of Canada, at Langham, Sask. on Ceepee Bridge constrn. (*St. 1931.*)

References: C. J. Mackenzie, F. G. Goodspeed, R. A. Spencer, E. K. Phillips, T. G. Tyrer.

DYMENT—JOHN TALBOT, of 105 Brighton St., Ottawa, Ont., Born at Barrie, Ont., Nov. 23rd, 1904; Educ., B.A.Sc., Univ. of Toronto, 1929; 1929-30, Ford engrg. lab., airplane divn., Dearborn; 1930 to date, junior engr., and for past 3½ years duties as asst. engr., aeronautical engrg. divn., Dept. of National Defence, Ottawa, Ont. (*St. 1925.*)

References: E. W. Stedman, A. Ferrier, J. H. Parkin, B. G. Ballard, D. G. McCrone, A. T. N. Cowley.

TOLLINGTON—GORDON C., of 351 Charlotte St., Peterborough, Ont., Born at Claresholme, Alta., Oct. 8th, 1907; Educ., B.Sc. (E.E.), Univ. of Alta., 1932; 1929-30 (summers), engrg. dept., City of Calgary; 1930 (summer), electric light dept., City of Calgary; 1934-35, students test course, and 1935 to date, induction motor engrg. dept., Can. Gen. Elec. Co. Ltd., Peterborough, Ont. (*St. 1932.*)

References: V. S. Foster, A. L. Dickieson, R. E. Hinton, H. R. Sills, B. Ottewell.

### FOR TRANSFER FROM THE CLASS OF AFFILIATE

HURST—ALBERT DOUGLAS, of Gravenhurst, Ont., Born at Gravesend, Kent, England, Dec. 28th, 1885; 1900-1903, School of Science and Arts, Gravesend Home study in bldg. constrn.; 1903-07, ap'tice, H. Waterman, contractor; 1907-08, improver, H. H. Carter, Co., Grays, Essex; 1908-09, Wm. Gray Constrn. Co., London, England; 1909-11, supt., Robins Ltd., Hamilton, Ont., and 1911-13, for their successors, Crompton & Crompton on erection of homes; 1913 to date, on mech'l. staff, National Sanitarium Association, Gravenhurst, Ont., last twenty years as gen. foreman, and at present mech'l. supt. (*Affiliate 1936.*)

References: L. G. McNiece, J. Walker, D. C. M. Hume, W. P. Dale, C. Connell, H. M. Cawthra-Elliott.

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*All correspondence should be addressed to*

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## Situation Vacant

SALES ENGINEER. Manufacturer of heavy electrical apparatus has vacancy for a man who should preferably have established connection with public utilities and Industry. Reply should give detailed particulars in first instant, including age, education, engineering and sales experience and details of sales territories acquainted with. Apply to Box No. 1461-V.

EXPERIENCED SALESMAN required for province of Quebec by a manufacturer of electric motors, transmission and switchgear. Apply to Box No. 1470-V.

JUNIOR ENGINEER, required at Montreal for estimating and specification work by manufacturer of electric motors, transmission and switchgear. Should have commercial ambitions and electrical education. Good prospects for keen young man. Apply to Box No. 1471-V.

SERVICE ENGINEER, required for Montreal and district by electrical machinery manufacturer. Should have aptitude for soliciting orders for electric repairs and rewinds. Apply to Box No. 1472-V.

CIVIL OR MECHANICAL ENGINEER preferably with two or three years experience for a pulp and paper mill in Ontario. Apply to Box No. 1473-V.

NATIONAL RESEARCH COUNCIL

The Associate Committee on Radio Research invites applications for a temporary assistant in the Radio Section of the National Research Council. Appointment is to be made for a period of one year commencing April 1st; salary about $1,800 per annum.

*Qualifications:* University graduate in electrical engineering, radio engineering or engineering physics, or honours graduate in physics with special radio training.

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Applications should be in the hands of the Secretary-Treasurer, National Research Council, not later than February 27th. Particulars of the candidate to include age, race, nationality, training, experience and references.

## Situations Wanted

ELECTRICAL ENGINEER, B.Sc., E.E. Age 30. Completed C.G.E. Test Course; five years experience with power company utility work—substation and power house (steam) operation and maintenance, transmission and distribution line operation, maintenance and design. Industrial or utility work desired. Location immaterial. Available on short notice. Apply to Box No. 266-W.

MECHANICAL ENGINEER, B.Sc. Age 31. Married. Last ten years includes:—Mechanical structural and reinforced concrete design in pulp and paper mills, industrial plants, hydro-electric, mine, sewers and sewage disposal plant construction. My experience also includes shop production, steam plant combustion, fuel analysing, inspecting, supervising and instrument work on industrial construction. Permanent position preferred. Apply to Box No. 521-W.

DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aero-photographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.

DESIGNING ENGINEER AND ESTIMATOR, grad. Univ. of Toronto in C.E., A.M.E.I.C., twenty years experience in structural steel, construction and municipal work. Available at once. Apply to Box No. 613-W.

ELECTRICAL ENGINEER, B.Sc. '28; M.Eng. '35. Two years student apprenticeship at Can. Westinghouse Co., including test and electrical machine design. Also about two years experience in operating dept. of large electrical power organization. Available on short notice. Apply to Box No. 660-W.

## Situations Wanted

ELECTRICAL AND CIVIL ENGINEER, B.Sc. Elec. '29, B.Sc. Civil '33. Jr.E.I.C. Age 29. Experience includes four months with Can. Gen. Elec. Co., approximately three years in engineering office of large electrical manufacturing company in Montreal, the last six months of which was spent as commercial engineer. For the last year and a half employed in electrical repair shop. Best of references. Apply to Box No. 693-W.

CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C. Experience includes three seasons in charge of survey party. Transitman on railway maintenance, and concrete bridge designing. Nature of work and location immaterial. Apply to Box No. 724-W.

YOUNG CIVIL ENGINEER, B.Sc. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

MECHANICAL ENGINEER, S.E.I.C., B.A.Sc., Univ. of B.C. '30. Single, age 24. Sixteen months with the Allis-Chalmers Mfg. Co. as student engineer. Experience includes foundry production, erection and operation of steam turbines, erection of hydraulic machinery, and testing texropes and centrifugal pumps. Location immaterial. Available at once. Apply to Box No. 735-W.

### Employment Service Bureau

Enquiries continue to be received for young engineers, particularly with mechanical training or experience, engineers with pulp and paper mill experience, and sales engineers speaking French.

In the months of December and January employment bulletins were sent to members whose names are on the active list of the Employment Service Bureau, listing all positions vacant at the time that could be advertised.

Unfortunately, many of these positions were of a transitory nature or could be filled on short notice and therefore did not warrant insertion in the Journal, as from ten days to two weeks and even longer might elapse before the date of mailing and receipt of replies.

Your attention is called to the annual report of the Employment Service Bureau appearing on page 73 of this issue of the Journal.

RADIO AND ELECTRICAL ENGINEER, B.Sc., '31, Jr.E.I.C. Single. Age 29. One year and a half actual field experience in power and lighting equipment. Extensive work in telephone and radio layouts in switchboard and installation depts. Particularly interested and experienced in sales and traffic work in telephone and radio company. At present supervisor over sales and service of radio and electrical company. Available on short notice. Location immaterial. Apply to Box No. 740-W.

PLANT ENGINEER or SUPERINTENDENT, capable of supervising all phases of industrial plant operation, graduate electrical, eleven years diversified industrial experience including test course, four years on large Quebec industrial development, on construction and operation, also six years with prominent consulting firm supervising electrical and mechanical engineering projects. Age 31, single. Apply to Box No. 795-W.

CIVIL ENGINEER, B.Sc. '15, A.M.E.I.C., married, extensive experience in responsible position on railway construction, also highways, bridges and water supplies. Position desired as engineer or superintendent. Available at once. Apply to Box No. 841-W.

## Situations Wanted

STRUCTURAL ENGINEER, B.A.Sc., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

CIVIL ENGINEER, B.A.Sc., Jr.E.I.C., age 32, married. Two years in pulp mills draughting and designing additions, maintenance and plant layout. Three and a half years in the Toronto Building Department, checking and designing for steel, reinforced concrete and ordinary structures. One and a half years as transitman and draughtsman on road location and maintenance work. Available at once. Location immaterial. Apply to Box No. 899-W.

CIVIL ENGINEER, B.Sc., O.P.E. Experience includes several years on municipal work-design and construction of sewers, steel and concrete bridges, watermains and pavements. Available at once. Apply to Box No. 950-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.

ELECTRICAL ENGINEER AND GEOPHYSICIST. B.Sc. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No. 1168-W.

ELECTRICAL ENGINEER, B.Sc. '34 (Univ. of N.B.), S.E.I.C. Age 21, single. Desires any kind of electrical work. Will consider any location. Apply to Box No. 1262-W

ENGINEER AND DRAUGHTSMAN, Jr.E.I.C., age 33, married. Diplomas from Mtl. Tech. Inst. in R.C. and Structural Design. 11½ years experience in civil engineering, draughting and instrument work. This includes 7 years with M.L.H. & P. Cons. as field engineer on construction and maintenance of gas mains. Present location Montreal. Available at once. Apply to Box No. 1326-W.

CIVIL ENGINEER, M.E.I.C. Married. Age 38. Twenty years experience in organization, design and estimating, and cost accounting. Active service in France. Apply to Box No. 1367-W.

ENGINEER SUPERINTENDENT, A.M.E.I.C., R.P.E., Que. and Alta. Age 47. Married. Twenty years experience as engineer and superintendent in charge of hydro-electric, industrial, railroad, and irrigation construction. Specialized in rock excavation and suction dredging. Intimate knowledge of costs, estimating and organizing. Available immediately. Apply to Box No. 1411-W.

CIVIL AND ELECTRICAL ENGINEER, Univ. of Man. '35 and '36. S.E.I.C. Experience in irrigation and mapping. Available at once. Location immaterial. Box No. 1418-W.

CIVIL ENGINEER, B.Sc. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

SALES ENGINEER, M.E.I.C. Age 50. Married. Several years in combustion and general machinery lines. Estimating and layout work (mechanical and electrical). Speaking French fluently. Executive ability. Apply to Box No. 1482-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.Sc. '31 (Univ. of Alta.), Jr.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work, location immaterial and available at once. Apply to Box No. 1522-W

## Transport Legislation in Argentina

A National Co-ordination of Transport Bill has now passed the Argentine Senate, and only awaits promulgation in order to become law. This measure is a valuable example of the "benevolent treatment" which has been promised to British capital by the Argentine Government. It provides for the appointment of a National Commission for Co-ordinating Transport, which will consist of seven members and will be the authority from which all public motor-transport services carrying passengers or goods, except those operating within the bounds of a single province, must obtain licences. In considering applications for licences the Commission will take into account public necessity in the district to be served, and will arrange to avoid duplication and to ensure that preference is given to carriers who provide a continuous service under the best conditions as to price and time. A road maintenance fund is to be created by a tax varying from £6 to £25 for each vehicle. Tariffs must be approved by the Commission, and routes, schedules, wages and general working conditions will also come under strict control. The advancement of the Bill to its present stage has only been effected in face of energetic and continuous opposition. This has mainly taken two forms: One that the measure is directed against the working classes in the interests of foreign capital; and the other that the railways have now largely served their purpose and must make room for other forms of transport. It is pointed out, however, that the interests of the small man are adequately safeguarded, and that the railways are still essential for the transport of bulky goods in large quantities. In railway circles in London, in fact, the Bill is regarded as an important step towards the elimination of wasteful road competition. As it is, the complete freedom under which road transport has operated in Argentina in recent years has led to the creation of a multitude of small mushroom companies whose services have often been run without regard to ultimate commercial results. Thus, no allowance has been made for depreciation, and there has been much fare cutting and picking and choosing of freights. Fortunately, there has been an increasing recognition of the fact that in spite of the foreign capital involved, the railways actually carry 90 per cent of both the exports and imports of Argentina, and that they still have a great part to play in the development of the national resources of the country.—*Engineering.*

## Canadian Chemical Association

The annual convention of the Canadian Chemical Association and the Canadian Institute of Chemistry is to be held in Vancouver on June 17th, 18th and 19th, 1937.

Plans are being made for a special train to leave Toronto and Montreal on Friday evening, June 11th, spending a few hours in Winnipeg on Sunday morning, then on to Kimberly where the Sullivan Mine, the greatest silver-bar mine in the world, will be visited. The following day the Consolidated Mining and Smelting Company's plant at Trail, B.C., will be visited and the special train will arrive in Vancouver on Wednesday evening. The all-inclusive expense of this trip is estimated at $200.

More complete information as to the programme will be released later, and in the meantime, those seeking more detailed information as to itinerary and cost should address their enquiries to Dr. R. I. Elworthy, Secretary, Canadian Chemical Association, 366 Adelaide Street West, Toronto, Ontario.

## Changes in Employment

Some striking changes in the distribution of employment in Britain during the last thirteen years are shown in statistics recently issued by the Ministry of Labour. The biggest proportionate increase in employment since 1923, 70.1 per cent, has been in miscellaneous services. These include professional services, entertainments and sports, hotel, public-house, restaurant, boarding house, club, etc. service and laundries, dyeing and dry-cleaning.

Next comes building and contracting, with a gain of 62.7 per cent compared with July, 1923. Then comes transport, communication, storage and distribution up 47.4 per cent. Fishing shows an advance of 44.1 per cent, gas, water and electricity supply 27.2 per cent, national and local government 25.6 per cent, and commerce, banking, insurance and finance 16.3 per cent. Manufacturing accounts for half the insured work people in the country, 6,188,690 out of a total of 13,338,700. This group shows the smallest proportionate increase, 8.3 per cent, but in this group, of course, are included industries which have greatly expanded and others which have greatly contracted. The only decrease is shown by mining and quarrying, where there is a fall of 23.6 per cent. The total number of insured work people increased by 19.5 per cent over the period.—*Industrial Britain.*

## Young College Graduates and Steel Companies

Nearly one thousand college trained men are expected to find jobs open to them in the steel industry in the United States when they graduate this spring, according to estimates made by the American Iron and Steel Institute.

The number of such youths going into the steel industry this year will be larger than ever before, reflecting the expanding operations and increased employment in the industry. Most of them will be from technical and engineering schools.

A number of steel companies have organized plans for recruiting college trained men, close contacts being maintained with various institutions for that purpose. Likely candidates for jobs are selected from among the graduating classes. Some companies also are planning to offer opportunities for summer training in the mills to undergraduates.

More than 70 per cent of the college men hired by one leading steel company in the past thirteen years have held degrees in engineering. About 13 per cent of them were bachelors of arts or of science. Included in the remainder were specialists in economics, marketing, architecture, journalism and law. The men were graduated from some 102 colleges, universities and technical schools.

The degree most commonly held was that of mechanical engineer, received by 149 of the men. Other degrees were in chemistry and chemical engineering, 97; civil engineering, 95; metallurgical engineering, 70; mining, 57; bachelor of arts, 45; electrical engineering, 42; and bachelor of science, 38. More than 100 had specialized in or had received degrees in business administration, industrial engineering, or affiliated subjects.—*Steel Facts.*

# THE ENGINEERING JOURNAL

## THE JOURNAL OF THE ENGINEERING INSTITUTE OF CANADA

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*"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."*

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## CONTENTS



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## Some Features of Mining Geology

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**An Address delivered before the Halifax Branch of The Engineering Institute of Canada, November 19th, 1936.**

SUMMARY.—After naming various classes of ore-bodies, the author gives notes based on his visits to the pyrite deposits of Rio Tinto and Sulitelma, briefly discusses the mining regions of Northern Rhodesia and the Belgian Congo, and mentions some of the important factors to be borne in mind in estimating the worth of a mining venture.

The problem that confronts every mining engineer or mining geologist sometime during his career involves the question of finding new ore-bodies which will prolong the life of his mine.

To answer this question it is necessary to know how ore-bodies are formed. What processes have resulted in the formation of ore? To gain some knowledge of that problem it is necessary to study the conditions in various types of deposits and then attempt some classification which is based on genesis. The author has adopted the following classification, which he presents with the hope that it may be helpful:—

A.—Surface deposits. The result of mechanical forces such as stream action but not excluding some chemical action.
1. Alluvial—e.g. Placers. The valuable minerals have been washed from their parent rock and concentrated by conditions resulting from slackening currents and differences of specific gravity.
2. Residual—The host rock has been washed away leaving a concentration of the minerals of economic value.

B.—Deposits resulting from supergene action, chiefly chemical.
1. Syngenetic—e.g. Wabana iron ores of Newfoundland, gypsum and salt deposits of Nova Scotia.
2. Epigenetic—The only genuine example of this type studied by the author is a deposit of barytes near Glencar, County Sligo, Ireland. It is a comparatively rare type.

*Note*—Supergene action is equivalent to surface effects; it is to be contrasted with hypogene action which suggests effects produced from depth.

Syngenetic means contemporaneous and epigenetic means later than.

C.—Deposits resulting from hypogene action—chiefly chemical.
1. Syngenetic—
   (*a*) In lavas—Some copper and zeolite deposits.
   (*b*) In dykes—Pegmatite and other dykes frequently carry minerals of economic importance.
   (*c*) In plutonic or deep seated igneous rocks. Examples are Sudbury (in Canada), Kiruna (Sweden), Bushveld igneous complex (Transvaal).
2. Epigenetic—Hydrothermal and gaseous agents.
   (*a*) In veins—Very common.
   (*b*) In zones—Some of the largest ore-bodies such as Rio Tinto and the great Northern Rhodesian copper mines.
   (*c*) In stockworks, i.e. intersecting veinlets cutting the country rock. Some of the Rio Tinto deposits.
   (*d*) Volcanic emanations. Sulphur in Sicily.

*Note*—(*a*), (*b*) and (*c*) chiefly formed by hydrothermal solutions, (*d*) chiefly gaseous.

The problem of finding ore resolves itself into first classifying the deposit and then trying to imagine the passages which the ore carriers followed to their final destination. Having set up a working hypothesis the next step is to test its validity by directed exploration.

**Fig. 1—Rio Tinto. Atalaya Opencast. Porphyry on the Right, Slate on the Left, with Ore Between.**

In connection with all the epigenetic hydrothermal deposits a complication enters into the general picture. This complication is the observed fact that the values in a vein are not co-extensive with the vein. The values form shoots whose boundaries are often only determinable by chemical analysis. What do these shoots represent? It has been suggested by Douglas, Howse and Sheppard*

*Concerning Ore-Shoots—Bull. C.I.M.M. 1934.
Further Notes on Ore-Shoots—Bull. C.I.M.M. 1935.

that these shoots are the loci of channel ways which were open at the time when the solutions were charged with the ore minerals. This conception involves the idea that the solutions were differently charged at different times. There is justification for this idea in the observed zoning of many mineral deposits, notably those in Cornwall, England. Closest to the parent igneous rock are to be found such minerals as tinstone and wolframite, further out chalcopyrite and still further out galena. These minerals as

**Fig. 2—Rio Tinto. View of Smelter Stacks.**

arranged are also in decreasing order of hardness and it would appear that this same order is that in which they were given off from the parent rock and travelled through the possible openings available at the time. The last sentence shows the importance of structure, for as soon as the solutions leave the source rock the structure of the host rocks to a great extent governs the permeability and locus of deposition. Examples of some of these types will now be cited.

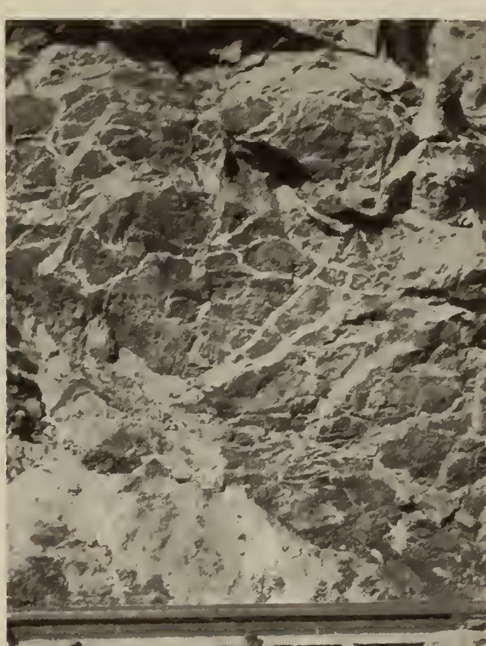


**Fig. 3—Stockwork Porphyry on Footwall of San Dionisio Orebody. The White Veins are Massive Pyrites.**

## Rio Tinto

These ancient mines which have been worked off and on for over two thousand years are situated in the province of Huelva in south-western Spain. Iberians, Phoenicians, Romans, Swedes and British have worked these mines which have yielded pyrites, copper, gold and silver. (Figs. 1 and 2.) The ore-bodies may be grouped into the following classes:—

(*a*) Massive sulphides with slate walls, as lenses and veins.
(*b*) Contact bodies between porphyry and slate.
(*c*) Stockwork and disseminated sulphides entirely in porphyry.

These three classes are not to be thought of as isolated but rather as forming one large scheme.

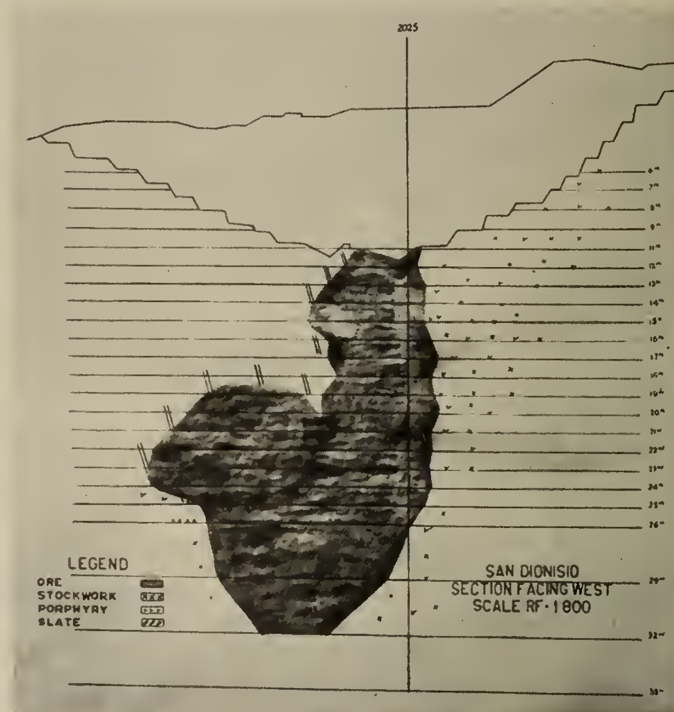



**Fig. 4—San Dionisio Orebody. Footwall to Hanging Wall approximately 200 Metres.**

An idealized section would show a stockwork porphyry passing upwards into massive sulphides at the contact and above this zone, entirely in slate veins and lenticles of sulphides. (Figs. 3, 4 and 5.)

The important point to be noted with regard to the location of the ore-bodies is that the slaty cleavage was developed before the porphyry or ore solutions were introduced.

The porphyry was injected as sills and as wedge dykes. In the latter case one flank of the dyke undercuts the slaty cleavage which dips north and the other flank lies parallel to the cleavage. As a matter of observed fact the ore lies at the undercut contact. The other contact is barren. Stated another way, the slates are permeable edge on but are impermeable normal to their dip. A realization of this structural control facilitates the finding of new ore-bodies.

Both opencast and underground methods are employed in the mining of these enormous masses. It is found that opencast mining is much cheaper than underground methods for lodes of this type. The ratio of overburden to ore that makes opencast methods feasible is dependent on a number of factors.

The ratio is a function of:—

1. Depth of cover
2. Toughness of rock
3. Angle of repose
4. Cost of transport
5. Amount of ore to be won.

The following table is from data obtained at the mine.

| Nature of Rock | Tons of Rock to | Tons of Ore |
|---|---|---|
| Porphyry and hard slate............... | 3.8 | 1.0 |
| Soft slate........................... | 5.5 | 1.0 |

The largest of the Rio Tinto ore-bodies is San Dionisio. The cross-section of this mass is shown in Fig. 4 and its size may be realized when it is stated that from footwall to hanging wall at its widest point the ore-body is nearly 200 metres in width, the whole of that distance being massive ore.

Rio Tinto was one of the first, if not the first place where leaching was practised. Some of the ore is spread out over the surrounding country and is sprayed with mine waters. These waters carry sulphates of iron and copper and also sulphuric acid. The copper in the ore, if it be in the form of bornite, chalcocite, covellite or as oxide copper is leachable. The liquors are caught in reservoirs and are then passed over iron scrap. The sulphate solutions deposit copper at the expense of iron (Fig. 6). The iron sulphate is rejected and flows into the river together with considerable zinc sulphate. The colour of the river is at first green, due to the ferrous state of the iron, but after passing over some small rapids it is oxidized and hence the river enters the sea a brilliant red colour.

Under the management of W. A. Carlyle and W. J. Browning, Rio Tinto set the price of sulphur on the Atlantic seaboard and also was one of the world's cheapest producers of copper.

At the present time, due to political difficulties in Spain, the cheapness of Gulf sulphur and the discoveries of the large copper deposits in Africa and South America, the mine is not in such a favourable position. However its long history, present reserves and accessibility still make it one of the great potential mines of the world.

A partial bibliography of Rio Tinto references is given at the end of this paper.

### Norway

There are some extremely interesting pyritic mines in the Scandinavian peninsula; Orkla near Trondhjem and Sulitelma which is north of the Arctic Circle and can be

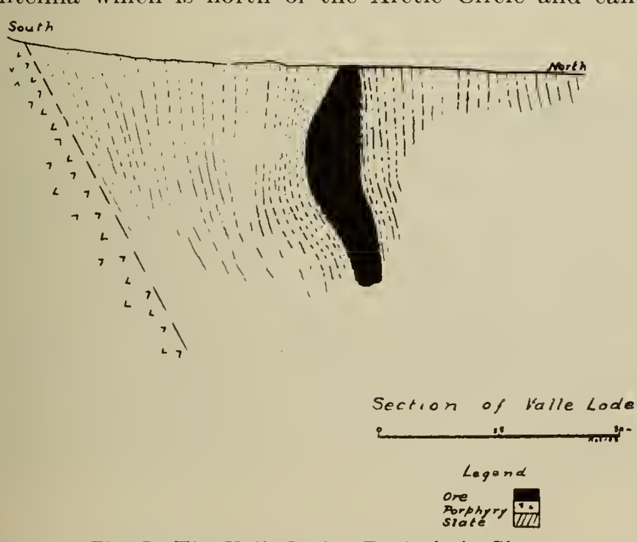



Fig. 5—The Valle Lode. Entirely in Slate.

reached from the port of Bôda. Both of these mines have considerable reserves of good ore and are worked by very capable engineers.

Sulitelma is a broad mineralized anticline. Figure 7 shows its cross-section. The crest of the anticline has been eroded and the ore is being won from the flanks. The country rock is a schist which has been invaded by sheets of gabbro. The ore is in schist which it replaces and frequently there is a gabbro sheet above the ore-body. Sometimes this sheet lies below the ore.

The sections of the ore-body at Sulitelma give some useful criteria for replacement. There are numerous inclusions of schist in ore. These inclusions have the same orientation as the walls. In the walls there are veins and lenticular pods of ore up to two or three metres in length, detached from the massive ore. The massive ore has no

Fig. 6—Cementation Launders where Copper Liquors pass over Scrap Iron.

chilled margins, which would be expected if the ore had been intruded as a magma or molten mass from below.

The ore at Sulitelma is brought down to the rail level from the hillsides by buckets on rope conveyors operated by gravity.

At Orkla one of the mining features which impressed the author was the bifurcating shoot leading from the haulage level to the shrinkage stopes. This double arrangement prevents a holdup in the drawing of the ore, for if one shoot jams the ore runs through the other until it is possible to remove the obstruction.

### Africa

In Northern Rhodesia and the Belgian Congo there lies one of the greatest copper deposits known in the world. In the Congo there are mines occurring at intervals over approximately four hundred miles. These bodies are chiefly composed of oxide copper—malachite, azurite chryscolla, cuprite and tenorite. Associated with these copper minerals there are cobalt minerals and in some of the deposits radioactive ores.

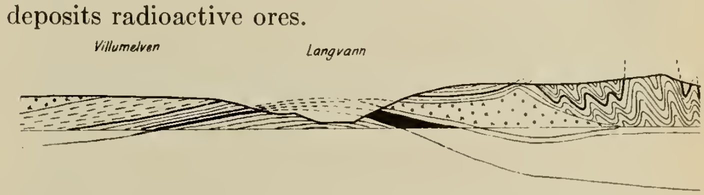



Fig. 7—Section Sulitelma. The Ore lies below the Black Bands.

These deposits, which are enormously rich, represent the concentration of oxide minerals by surface waters. The original minerals are believed to have been sulphides of hypogene origin which by exposure were oxidized and later concentrated by solution and reprecipitation.

This mineralization occurs in a remarkably uniform series of rocks, Precambrian in age. These rocks are sediments which include arenaceous, argillaceous and calcareous types. Robert's column of the beds forming the Série des Mines with the thickness in metres follows:—

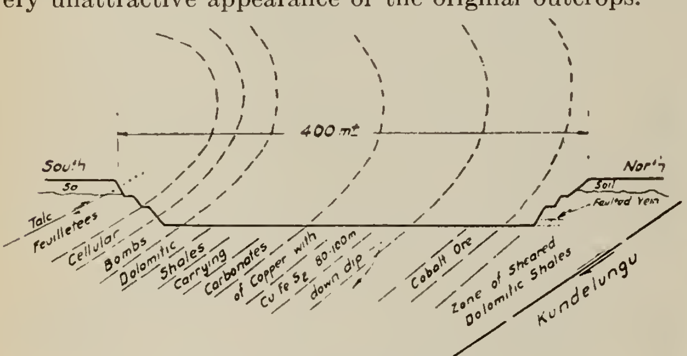
| | |
|---|---|
| Dolomite.................. | 200 to 400 metres |
| Dolomitic shales.............. | |
| Cellular quartzite............ | |
| Banded quartzite............. | |
| Inferior shales............... | |

This column gives the key to the structural interpretation of the Congo mines, because the cellular quartzite is a very easily distinguished rock, being white and porous. Below it is the dense banded quartzite or feuilletées. These two rocks are markers and if they are found inverted it can be taken that the beds have been overturned. Figures 8, 9, 10 and 11 give some idea of the structure and size of these large bodies.

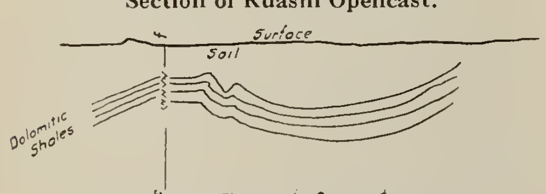
Fig. 8—The Ruashi Mine, Belgian Congo.

Turning now to the Northern Rhodesian mines we have to deal with a predominantly sulphide mineralization.

The minerals are chalcopyrite and bornite with chalcocite and covellite. The first mineral to be deposited was linnaeite which is a cobalt sulphide. The ores are hypogene and are disseminated in the country rock which is principally shale. The appearance of the ore in some of the mines is decidedly non-spectacular; it often requires a very careful scrutiny or use of a hand lens to see the sulphides. It will always be to the credit of the original finders of these deposits that they did recognize possibilities in the very unattractive appearance of the original outcrops.




Section of Ruashi Opencast.




Section of West End Ruashi.
Fig. 9

The mineralization occurs where these sedimentary beds have been cut by granite. The ore does not occur very close to the contact nor does it form an aureole around the intrusion but rather certain beds which offered passages for the solutions given out from the granite are mineralized for considerable lengths in their vicinity. The sediments had been folded prior to mineralization and subsequently eroded, so that the crests of the anticlines have disappeared. The mineralized beds have therefore only been preserved in the limbs and troughs of the synclines. It is interesting to speculate about the enormous tonnage which must have been lost due to erosion of the anticlinal crests.

The chief Northern Rhodesian mines are as follows:—

| Mine | Owner | Tonnage | Tenor |
|---|---|---|---|
| N'Kana, Mindola | Rhokana | $127 \times 10^6$ | 4%± |
| *N'Changa | Rhokana | $144 \times 10^6$ | 7%± |
| Roan Antelope | Selection Trust | $104 \times 10^6$ | 3.4% |
| Mufulira | Selection Trust | $116 \times 10^6$ | 4.4% |
| Chambishi | Selection Trust | $25 \times 10^6$ | 3.4% |
| Baluba | Selection Trust | $21 \times 10^6$ | 3.4% |

*Some of the N'Changa ore must be considered as oxide copper ore.

For those who wish to delve further into the geology of these areas the bibliography at the end of this paper may be helpful.

It is obviously impossible in a paper of this character to do more than touch on some points here and there which appear to be relevant to the subject. Regarding Canada the author does not intend to describe any specific mines but to confine himself to some opinions.

The first opinion is that Canadian mines are not paying dividends at a sufficiently high rate. The result of this low rate is for the investing public to buy mining stock hoping that it will rise and thus pay for the venture. There are of course exceptions to this statement but in general the statement is true.

A well known mining engineer in London told the author that in his opinion, considering the risks involved, an investor should receive ten per cent on his money. Hoover's figures are approximately the same.

Secondly, it is the practice in Canada, also with exceptions, not to state the general reserves. This omission also leads to speculation and not to sound investment. It is impossible to calculate the real value of any mining shares unless the following data are given:—

(*a*) Total reserves.
(*b*) Tonnage mined per annum.
(*c*) Net profit per ton.
(*d*) Number of shares issued.

Fig. 10—The Chituru Mine, Belgian Congo.

Given these data the calculation is as follows:—

$$\frac{(a)}{(b)} = \text{"}n\text{" years or life of mine.}$$

$$(b) \times (c) = \$ \text{ "}A\text{" which is the yearly profit.}$$

The present worth of \$ "*A*" for "*n*" years expecting 10 per cent return and 4 per cent redemption can be obtained from the formula

$$\text{Present worth} = \frac{A}{\dfrac{(0.04)}{(1 + 0.04)^n} + 0.10}$$

or from tables given in Hoover's Principles of Mining or Baxter and Parks Mine Valuation.

The present worth divided by the number of shares issued (*d*) gives the real value of the shares.

If the investing public would only demand these data and take the trouble to do a little arithmetic the Canadian mining industry would be on a much sounder and healthier basis than it is at present.

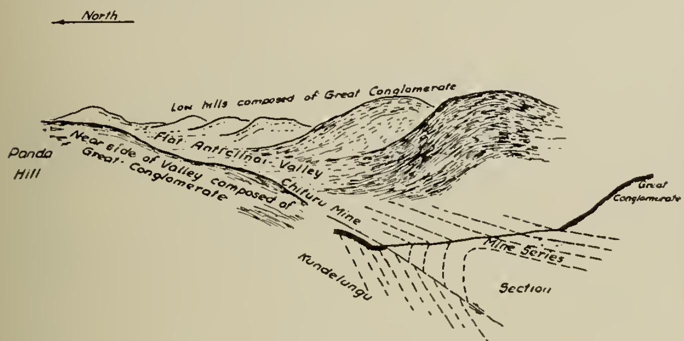



**Fig. 11—Sketch of Chituru Mine.**

In Nova Scotia there are numerous cases of well meaning persons embarking on mining ventures where there is no real hope for success. The glitter of gold dazzles their judgment. The veins on the average are narrow and it requires very careful planning to make these ventures pay. Too much attention cannot be paid to the question of tenor.

As a rough guide in deciding on which veins are possible and which are doubtful the author has plotted the following curves. They can be used in a number of ways (see Figs. 12, 13 and 14).

For example a vein is found with a certain width and by careful sampling the tenor has been obtained. (Tenors of 0.25, 0.50, 0.75 and 1.0 oz. per ton have been used.) Each of the three sets of curves has these four tenors. Find the point on the curve which corresponds to the width of the vein and the known tenor. If the point is above the abscissa on all three sets it is possible that the vein may be of commercial value. If the point is below on one set and above on another it means that the cost of mining will have to be considered very carefully for it will lie between $3 and $4 or $4 and $5 per ton.

These curves show the minimum widths of veins of various gold tenors with assumed total mining costs of 3, 4 and 5 dollars per ton.

The value of an ounce of gold is taken as $35.

One ton is taken as equivalent to 12 cubic feet.

Example—A vein carrying 0.50 ounce gold per ton would require to have a width of at least 0.75 feet (or 9 inches) to be considered economic with mining costs at $5 per ton.

Milling costs are not included but if known may be applied to the curves by raising the abscissa (or line through 0, 1, 2, 3) for as many dollars as the cost of milling.

A further point which might be mentioned is that mining costs as reported are often very misleading. Cost per ton, cost per ton mined, cost per ton milled, etc., are common phrases in mining and financial reports. The really informative statement would be cost per ounce of gold produced, cost per pound of copper and so forth.

Anything which will tend to convince the world that we are proud of our mines, as we have a right to be, and are prepared to open all facts regarding the mines to the sunlight will be to be the good of the mining industry and to the good of Canada.

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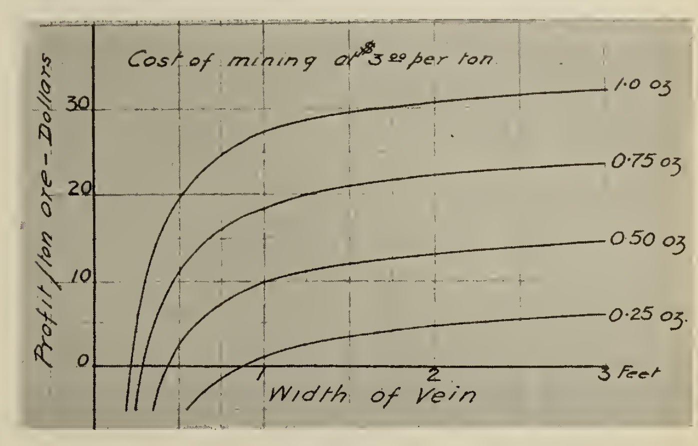


**Fig. 12**

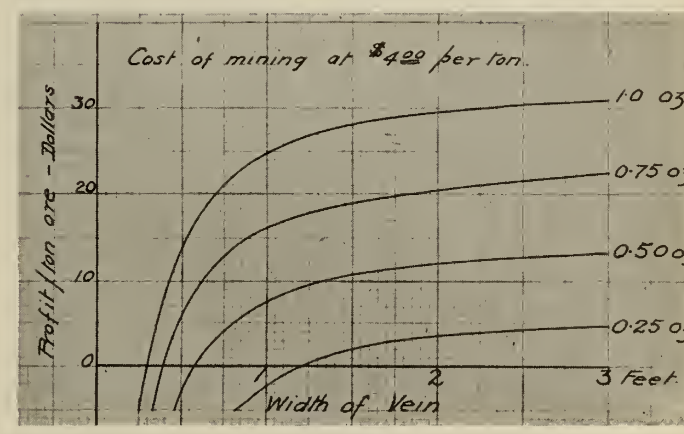


**Fig. 13**

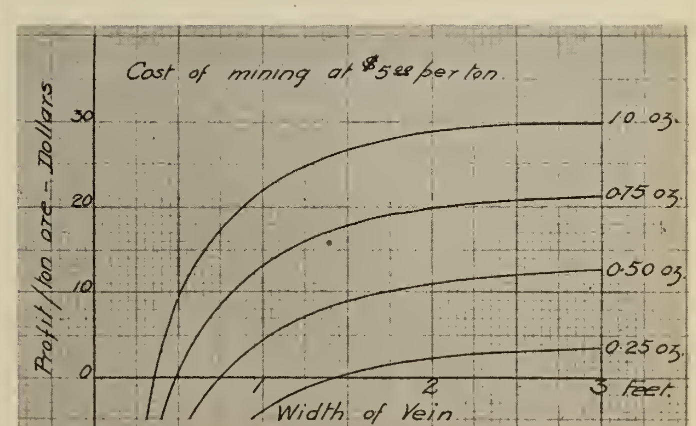


**Fig. 14**

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# Organized Labour and the Rationalization of Industry and Transport in England

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**An address delivered before the Ottawa Branch of The Engineering Institute of Canada, January 21st, 1937.**

**NOTE:—On a recent visit to England Mr. Waters was privileged to discuss organized labour with a number of labour leaders, business executives and politicians; and this paper is a summary of the views and facts which they kindly placed at his disposal. In this the author merely acts as a commentator, his own views not being introduced in any way.**

Organized labour in England has always considered that from a political economy standpoint it has developed further than labour in North America. In Canada and the United States we have regarded this claim with complacency in view of the lower standard of living in England. But at the present time there is little doubt but that this superior feeling of organized labour in England is justified; and we find labour leaders in that country taking a broad long range view of industry which is in contrast to the continual agitation for minor concessions that is so prevalent in certain other countries.

Several things have contributed to this; principally

(1) The public reaction to the general strike of 1926.

(2) The fact that a Labour Ministry had the responsibility of governing the country for several years, which had a sobering effect on labour leaders.

(3) The post war depression in foreign trade made labour realize that it is fighting foreign competition rather than capital.

When the necessity of rationalizing British industries to meet external competition first became evident, it was opposed by labour as resulting in unemployment due to the shutting down of obsolete plants and the introduction of labour saving machinery. But they soon realized that it is better to have a hundred men employed at good wages than a hundred and fifty at sweat shop rates; and that once an industry becomes prosperous it will expand, so that ultimately the additional fifty men who had to go on the dole, will be re-employed at living wages. Thus we now find organized labour in England favouring the rationalization of industries, consolidations, and the introduction of modern machinery. The "man-in-the-street" at times declaims against such developments. But the labour leaders know from experience that it is easier to negotiate with a single strong company that is prosperous, and to obtain concessions, than it is to fight a number of small concerns which are subject to demoralizing competition. They point to the cotton textile industry as typical of one which has only been able to pay low wages because of obsolete equipment in a number of independent plants, and antiquated trade practices. And they mention the chemical industries' trust as an example of a well managed prosperous enterprise which has virtually become a national institution, and which has treated labour well, while at the same time handling its market in a broad gauge manner; the only criticism being that its profits go to stockholders, and high private profits irritate labour.

Generally speaking, in the belief that it will ultimately permit of a shorter work week and higher wages without the necessity of raising prices, organized labour in England now encourages the modernization of plants and the introduction of labour saving machinery. It also favours unions covering a whole industry, as they permit dealing with conditions as a whole, while craft unions do not. There is a solidarity between labour unions, when labour considers it is fighting capital, but none when one industry is fighting another; a typical example of this being the sentiment of bus employees against cheap workmen's bus fares, based on the belief that such would lower profits and so prevent the payment of high wages to bus labour.

Apart from the rationalization of industries, the mental progress of labour leaders in England has been most evident in the way in which they have influenced new legislation in the transportation field.

The Labour Party in Great Britain is frequently considered to be the political branch of the labour unions. This is only true to a limited extent, as the Labour Party, though affiliated in a general way with the unions, is strictly a political party like the Conservative or the

Liberal; and the labour leaders are wise enough to keep themselves in a position where they are able to demand concessions from any party that happens to be in power. The members of the unions are conservative or radical according to their individual opinions; and only on rare occasions does labour vote as a solid political party. This desire of the labour unions for freedom of action was evident when it was proposed in the Railways Act of 1921 that labour should be represented on the boards of directors of the amalgamated railway companies. The labour leaders saw that the responsibilities which would result from being represented on the directorates would restrict their independence of action; so they permitted this feature to be withdrawn when it was opposed by the railways. They were thus able to obtain equal representation with the railways on the wages boards, a continuation of the war time wages which were at about two and a half times the pre-war level, and the condition that no employee of five years standing should be dismissed as a result of the amalgamations without adequate financial compensation.

At that time the labour unions were strongly advocating the nationalization of the railways. But they soon saw the country was not ready for it, so they contented themselves with the thought that the amalgamation of the one hundred and twenty railways into four consolidated properties would tend to simplify nationalization at some future date, and that the Railways Act of 1844 permitted the State to acquire the railways at any time.

The negotiations connected with the Railways Act of 1921 were the first trial of the wings of the labour unions after the war-time responsibilities had caused them to break out of their pre-war rut; and in the fifteen years since 1921 they have learned much.

When the 1921 Railways Act was under discussion there was some vague talk that labour should share in the profits of the railways. The Act instructs the Rates Tribunal to set rates that would insure to the railways a standard return based on the 1913 earnings; and when any permanent annual net earnings in excess of this standard return became evident, 80 per cent of the excess was to be allotted to a reduction of rates and 20 per cent was to be retained by the railways as an increase in the standard return they were permitted to earn. Labour assumed that a considerable part of this 20 per cent would be captured by them as increased wages, and that this would be the labour share of the profits which had been mentioned. But severe highway competition developed, so that the railways no longer had a monopoly; and this, with the depressed condition of trade, resulted in low net earnings for the railways, and there never were any profits for labour. So labour supported the railways when in 1927-8 they applied for powers to enter the road transport field, and has since been active in forcing the regulation of road transport as to wages and operating conditions, and even in an indirect way in regard to rates; so that it is now an organized industry, and the early evils of cutthroat competition are disappearing. Further, labour began to consider that a complete monopoly of all public transport, (i.e. all freight and passenger transport for hire), was the only solution for the transportation problem in England.

Because of the development of the suburbs, requiring extensions to the underground railways which were not in condition to finance such, and the numerous independent pirate buses which were demoralizing the profitable short haul traffic, and the complaints of labour as to the erratic wage scales wherein some of the unprofitable enterprises were paying wages much lower than the prosperous bus lines, the problem of passenger transportation in the London Metropolitan area had gradually become a sore spot. Accordingly the Labour Government in 1930 introduced a Bill which consolidated under the London Passenger Transport Board all underground railways, buses and tramways, and pooled their receipts with those of the suburban traffic of the main line railway systems; and this Bill was passed by the new National Government through a predominantly Conservative House in 1933. The Bill covered all passenger transportation for hire in the metropolitan area, both municipal and privately owned, except taxi cabs; and as the taxi cabs are now suffering from the efficient competition of the Transport Board, and are beginning to complain, they may also be ultimately absorbed. Though the public was from experience quite satisfied as to the ability of a municipality to manage a simple undertaking such as an electric light plant or a local tramways, it was sceptical as to any politically controlled body operating such an important enterprise as the London Transport Board, which controls the entire passenger transportation for hire, except taxi cabs, of the London area of 2,000 square miles with a population of nearly ten million. And though the labour unions were still theoretically in favour of the nationalization of all transport facilities, the leaders were beginning to think that labour might be worse off under government operation, e.g. under a bureaucracy or a civil service such as the Post Office, than it had been under the Railways Act of 1921, and in the rationalized industries. Accordingly there was little opposition to the Bill which made the Board free from political control, and specified that its seven members should be elected by the Chairman of the London County Council, a representative of the London and Home Counties Traffic Advisory Committee, the Chairman of the Committee of the London Clearing Bankers, the President of the Law Society, and the President of the Institute of Chartered Accountants, acting as Appointing Trustees. So that the principal labour criticism of the Bill was directed against the prices paid for the absorbed properties, on the grounds that paying dividends on excessive capitalization takes money that should go for higher wages. But the labour leaders realized that debentures and loans could not be disturbed without injury to the whole financial system of trust funds, insurance investments, charitable endowments, etc., and so concentrated their disapproval on the "C" stock of the Transport Board (limited to 6 per cent dividends if earned), which was given in exchange for the equity or goodwill of the absorbed properties. The government has since recognized the justice of this labour criticism as to the burden of high capital charges, by loaning the Board funds for extensions and improvements; thus offering it one of the most important advantages claimed for State ownership, viz., cheap money.

The clause in the Railways Act of 1921 which ruled that no employee of five years standing at the date of passage of the Act could be dismissed as a result of the amalgamations without financial compensation had worked well. The railways had taken particular care to safeguard human relations and had relied on the natural loss by retirement and death to render possible the gradual development of the economies made possible by the Act, so that less than one-quarter of the decrease in employees had been due to men losing their jobs because of the amalgamations; though since 1930 a number have been laid off because of the depression. But in the London Transport Board Act labour obtained the concession that no employee of *two* years standing at the date of passage of the Act should be dismissed, instead of *five* years standing as in the Railways Act. Actually, however, the number of employees of the Transport Board has increased about three per cent in its three years of operation, due to extensions to the system. However, some incompetent employees who were penalizing earnings have been dismissed; it is interesting to note that labour sentiment endorsed this action, and that it also favours high fares so that the property will be prosperous and able to pay good wages.

The London Transport Board plan was regarded as an experiment to give mass passenger transportation at reasonable prices and avoid the dangers of government ownership. Apparently it has been successful. Labour has obtained a number of wage increases for low paid employees and better working conditions, because the Board was better able to give them than many of the constituent properties which were subject to severe competition. The public has benefited through numerous fare reductions and better services and facilities. And the Board is functioning in an efficient business like manner, free from political or local interference.

The next experimental trial of the idea of labour that all transport should be a regulated monopoly was the passage in 1935 of the North Ireland Road and Rail Transport Act which consolidated under a government appointed Board all passenger and freight highway transportation for hire in Northern Ireland (other than the Belfast municipal and a few minor properties), and pooled the receipts with the railways. The Act specifies that the commercial functions of the Board, i.e. services, fares, rates and charges, new facilities, pooling arrangements, etc., shall be under the Joint Committee consisting of three members appointed by the Board and three appointed by the railways. So that it is apparently the purpose of the Act that the management shall be partially in the nature of a public trust in which the important of the existing enterprises are represented.

Under the Motor Vehicles Acts of 1926-1934 the conditions of operation (excluding wages and rates) of all highway transport in Northern Ireland were already regulated by the Ministry of Home Affairs, and bus fares controlled by the Road Transport Tribunal. And under the 1935 Act the wages and rates of any local carriers that are authorized by the Act to operate and of any independent public carriers that the Board permits to operate, are apparently made subject to the jurisdiction of the same appeal tribunals which ultimately control the wages and rates under the Board operations.

A government-selected board, rather than one appointed by independent interests like the London Transport Board, was possibly decided upon because of the ten weeks rail strike in 1933, which indicated that the joint railways and labour councils were not working as smoothly in Northern Ireland as they had in England; and because some of the labour unions were still nominally advocating the nationalization of all forms of transport.

Like the London Transport Board Act, the 1935 Road Transport Act of Northern Ireland safeguarded against dismissal all employees of two years standing.

The Board is authorized to issue "A" stock to pay for the physical assets of the absorbed properties, and "B" stock (limited to 6 per cent dividends if earned), for equities or goodwill. But to meet the opposition of labour to taking over properties at high prices, practically all have been acquired at their appraised physical value; and though the first annual report (1936) has not yet been issued, it is understood that only a very minor amount of "B" stock has been authorized.

The idea of labour was that the plan would probably result in the abandonment of some of the weak railways; but that dismissed employees would be absorbed by the highway transport as it developed. And though the fact that six of the nine railways in Northern Ireland extend also into the Irish Free State had influenced the government decision not to consolidate the railways with the highway transport under the Board at this time, labour expects that ultimately a way will be found for the Board to take over all the railways; thus enabling the experiment of a complete monopoly of all passenger and freight transport for hire to be tried in a small section of the country where a failure would not have serious consequences.

We have accordingly three experiments in the monopoly of public transport which have resulted from the pressure of organized labour.

(1) The amalgamation of the English railways into four territorial systems under private ownership and management, which through the pooling of freight and passenger traffic between common points has practically eliminated rail competition; but which is still subject to independent highway competition.

(2) The London Passenger Transport Board, with its securities privately owned and its properties under a management which is virtually a public trust free from political interference, and operating a monopoly of passenger transportation for hire in the London area, with receipts pooled with the suburban railway traffic.

(3) The government appointed Northern Ireland Road Transport Board, with its securities privately owned and its receipts pooled with the railways, operating all highway passenger and freight transport for hire in Northern Ireland under a management which apparently will be partly in the nature of a public trust in which the important existing enterprises are represented; and which labour expects will ultimately absorb the railways, and so become a monopoly of transport in the territory.

However, none of these three is an absolute monopoly, as they are all subject to the competition of privately owned automobiles and trucks which are used exclusively in the owner's business or pleasure.

All three of these transport monopolies are privately owned. But to conciliate those who consider that capital charges penalize wages, the stocks of the London Transport and the Northern Ireland Road Transport boards are made redeemable at par after twenty to thirty years.

Organized labour in England is not afraid of monopoly, either in industry or transport, as it realizes from experience the economies it makes possible, and the benefits to labour which result from strongly organized prosperous consolidated properties; and it is satisfied that no monopoly, especially a public utility monopoly, can abuse its power; as if it attempts to do so, the public always develops an effective way to control conditions. The "man-in-the-street," however, still talks at times in favour of State ownership and operation of all public utilities; and the miners are advocating the nationalization of the coal mines. But labour leaders are satisfied that labour will fare better with the rationalization of industries under private ownership and management, than under the State; and though some of the labour unions are still nominally in favour of nationalization of all forms of transportation, the leaders believe that a transport monopoly of any size, at least in England, would be more likely to satisfy public needs and be able to pay good wages to labour, if it were conservatively capitalized and managed as a public trust, free from political interference and bureaucratic control, like the London Passenger Transport Board.

Socialists, radicals and communists would be satisfied only with State ownership and operation of both industry and transport. But though this sentiment is strong in some districts such as Glasgow and South Wales, its influence in the national labour councils, other than the miners, is small. As one labour leader said, "We are willing to have the communists with us, as they keep us 'pepped up' and do not disturb our policies." Delegates to labour conferences have occasionally endorsed communist or socialist motions. But they have done so on their own emotional impulse, without instruction from their membership. So that such spontaneous actions are without significance.

The labour leaders in England are level headed and have learned much in the last fifteen years. So that though they at times talk radically for the benefit of some of their fire-eating constituents, they are following a conservative far sighted policy, and they are able to keep their membership in line. So long as this condition continues, organized labour cannot fail to be a powerful constructive force in English national life, and to be considered with the middle classes as the backbone of the country.

* * * *

The following is of interest in connection with the paper as it is an extract from an address by John Marchbank, the General Secretary of the National Union of Railwaymen, the most important of the English railway labour unions, before the Wandsworth Technical Institute, London, October 23rd, 1936.

> "In the view of the trade unions, transport should be brought under one control on a national basis, and the experiment in the case of the London Passenger Transport Board tends to support the view that the complete organization of transport is a necessity which must materialize at some future date.
>
> Viewed broadly, it may now be stated that the State, by the march of events, has been compelled in the national interest to act as co-ordinator of transport. In this capacity, as evidenced by the Railways Act of 1921 and the London Passenger Transport Act of 1933, legal compulsion has been put upon private interests or statutory bodies in order to secure amalgamations, a step which has had the effect of diminishing the disadvantages which existed during the time uneconomic competition reigned supreme."

The following is from a letter to the author, dated December 29th, 1936, also from Mr. Marchbank, to whom the paper was submitted for comments.

> "Whilst it is true that the Trade Union Congress makes representations to the Government of the day, no matter whether it is Liberal, Labour or Conservative, it must not be overlooked that trade unions are affiliated direct to the Labour Party and use the machinery of the Labour Party to give expression to their political ideas."

A letter dated February 16th, 1937, received from Mr. Allan Meikle, President of the Winnipeg National Labour Council, and member of the Executive Board of the All Canadian Congress of Labour, reads in part:

> "I congratulate you upon having observed from a standpoint outside the labour movement what many have failed to discern owing to their subjective position. Some of us in Canada have been trying for a long time past to induce organized workers to make a more practical approach to their problems than that which is suggested by the theoreticians. Sooner or later I am convinced they will come around to our view."

The following is an extract from an undated memorandum from Mr. W. T. Burford, Secretary of the Canadian Federation of Labour, Ottawa:

> "Labour movements the world over owe so much to the workers organizations of Great Britain that the recent tendency of labour in that country to revert to its original empiricism is of profound significance. In his paper Mr. Waters comments on the change he has observed in British labour's attitude towards industrial rationalization. This and other changes indicate an abandonment of traditional doctrines, and, above all, an emergence from the habit of letting political theory dictate economic policy."

# Power Development in Northern Ontario

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**Paper presented before the Toronto Branch of The Engineering Institute of Canada on January 21st, 1937, and before the Kingston Branch on January 26th, 1937.**

SUMMARY.—The demand for power for mining and for the pulp and paper industry in Northern Ontario since 1916 has led to the development of many power sites on the rivers draining into Lake Winnipeg, James Bay, Lake Superior and Lake Huron. The various plants of the Hydro-Electric Power Commission in this area generated some 325,000 h.p. last December; they are described and the conditions of sale and utilization of their power are discussed.

The vast portion of Ontario lying north of the forty-sixth parallel of latitude, which skirts the northerly shore of Georgian bay, produces a considerable share of the world's supply of newsprint and metallic minerals, particularly gold and nickel, and this would not be possible without the provision of large amounts of low cost power, which is as vitally important to these industries of the north as it is to the commercial, manufacturing and domestic consumers in southern Ontario. With only a small percentage of the total population, northern Ontario has developed water power sites with installations totalling over 1,000,000 h.p., as against southern Ontario's installations totalling approximately 1,350,000 h.p., which latter figure includes 950,000 h.p. installed on the Niagara river. Of the 1,000,000 h.p. of developed sites in the north, in round figures about 800,000 h.p. is at present being absorbed, 400,000 h.p. by the pulp and paper industry, 300,000 h.p. by the mining and metallurgical industries, and 100,000 h.p. by municipal and manufacturing concerns.

In capacity of undeveloped sites, northern Ontario leads southern Ontario by 2,500,000 h.p. as against 1,800,000 h.p. This figure of 1,800,000 h.p. includes Ontario's share of the power available in the international section of the St. Lawrence river, estimated at 1,100,000 h.p., but does not include power from any further diversion of water in the Niagara river through a revision of the Boundary Waters Treaty. Ontario's share of the undeveloped resources of the Ottawa river is about 630,000 h.p., of which 250,000 h.p. is located north of the forty-sixth parallel.

## POWER RESOURCES OF NORTHERN ONTARIO

Before proceeding with some comments on the more interesting phases of power development in the north, and in order to provide a background for the subject, it is desirable to describe briefly some of the more important power rivers in this area, and to mention the principal operating plants, the uses to which the power from them is put, and the undeveloped resources of these rivers. Many of these are shown on the map in Fig. 1.

### Lake Winnipeg Drainage

*English River*—The English river is a tributary of the Winnipeg river with headwaters at Lac Seul, and has a drainage area of 20,000 square miles at its junction with the Winnipeg. The only power development constructed on this river is the plant at Ear Falls, at the outlet of Lac Seul, where one 5,000-h.p. unit is at present installed. The installation of a second 5,000-h.p. unit is now under way, the ultimate capacity of this site being 25,000 h.p. Below Ear Falls there are three undeveloped sites aggregating approximately 120,000 h.p.

*Wabigoon River*—The Wabigoon is a tributary of the English river on which three small developments with capacities totalling 6,000 h.p., owned by the Dryden Pulp and Paper Company, are installed.

*Winnipeg River*—The Winnipeg river flows from Lake of the Woods into lake Winnipeg, being joined by the English river a short distance east of the Manitoba boundary line. There are two developed sites, totalling 30,000 h.p., owned by the Keewatin Power Company, supplying power to pulp and paper mills at Kenora, and two others of 6,000 h.p. capacity owned by the Lake of the Woods Milling Company located at the outlets of the Lake of the Woods. Two undeveloped sites with a capacity of 80,000 h.p. are located between Lake of the Woods and the Manitoba boundary.

*Rainy River*—The Rainy river flows from Rainy lake into Lake of the Woods and on it is one development at Fort Frances, owned by the Ontario and Minnesota Power Company, supplying power to the paper mills in the vicinity.

*Seine River*—The Seine river empties into Rainy lake from the east and there are three developments on it, with a total capacity of 36,000 h.p., also owned by the Ontario and Minnesota Power Company, whose output is fed principally to the paper mills in the Fort Frances district.

### James Bay Drainage

There are several large rivers north of the Albany, of which the Severn, Winisk and Attawapiskat are the principal ones, with undeveloped power resources, from our present knowledge, in the neighbourhood of 200,000 h.p.

*Albany River*—The Albany river is at present our Northern frontier, the mines in the Pickle Crow area in this vicinity representing the farthest north producing mines in Ontario. With headwaters at lake St. Joseph, the river has a drainage area of 50,000 square miles at its mouth, and is exceeded in size in Ontario only by the Ottawa, Niagara and St. Lawrence rivers. The only existing development on the Albany is at Rat Rapids, at the outlet of lake St. Joseph, which supplies power to the mines in the Pickle Crow area some twenty-five miles to the north. The undeveloped sites on the Albany are capable of producing up to 300,000 h.p., while its principal tributaries, the Ogoki, Kenogami, and the Kabinakagami, have undeveloped sites with a potential capacity of 200,000 h.p.

*Missinaibi River*—The Missinaibi river joins the Moose river near sea level. There are no developments constructed on this river, but there are undeveloped sites with a potential capacity of 100,000 h.p.

*Mattagami River*—On the Mattagami river there are three hydro-electric developments owned by the Canada Northern Power Company, having a total capacity of 25,000 h.p., supplying power to the mines in the Porcupine area. A 9,000-h.p. plant at Smooth Rock Falls is owned by the Abitibi Power and Paper Company, and one of 55,000 h.p. capacity at Smoky Falls supplies power to the Spruce Falls Pulp and Paper Company's mills at Kapuskasing. With its tributary, the Kapuskasing, there are undeveloped sites aggregating 275,000 h.p. on the Mattagami river.

*Abitibi River*—The Abitibi Power and Paper Company own three plants on this river, Twin Falls with a capacity of 30,000 h.p., Iroquois Falls with 28,000 h.p., and Island Falls with 48,000 h.p., which supply power to the Abitibi Company's mill at Iroquois Falls. The Canyon plant, about twenty-four miles downstream from Island Falls, owned by the province and operated by the Commission, has an installation of 275,000 h.p. This plant supplies primary power to the mines in the Porcupine, Kirkland lake, and Sudbury districts, and surplus power for steam production to the Abitibi Company's mills at Iroquois Falls and Smooth Rock Falls.

### Lake Superior Drainage

*Kamanistiquia River*—There is a development of 35,000 h.p. on this river at Kakabeka Falls, owned by the Kamanistiquia Power Company, the output of which is absorbed in Fort William and vicinity, also an undeveloped site of 25,000 h.p. capacity.

*Nipigon River*—Two hydro-electric developments owned by the Commission are located on the Nipigon river at Cameron Falls and Alexander, with installations of 75,000 h.p. and 54,000 h.p., respectively. The output from these plants supplies power to the pulp and paper mills located at Port Arthur and Fort William, to these municipalities, and to the Little Long Lac and Sturgeon river mining areas to the northeast. There is an undeveloped site of 100,000 h.p. capacity available a short distance upstream from Cameron Falls.

*White River*—The White river has undeveloped sites of 40,000 h.p. capacity, but no developed sites.

*Michipicoten River*—On the Michipicoten river is a development of 22,000 h.p. capacity, owned by the Great Lakes Power Company, which supplies power to Sault Ste. Marie and vicinity, and undeveloped sites of 30,000-h.p. capacity.

*Montreal River*—On the Montreal river the Great Lakes Power Company are constructing a development and installing one 10,000-h.p. unit, the ultimate capacity of this site being 20,000 h.p. They have a lease on another site of equal capacity farther downstream.

### Lake Huron Drainage

*St. Mary's River*—The St. Mary's river connects lakes Superior and Huron, through a drop of 18 feet. Two developments owned by the Great Lakes Power Company of 42,000-h.p. capacity supply power to municipal and industrial customers in Sault Ste. Marie.

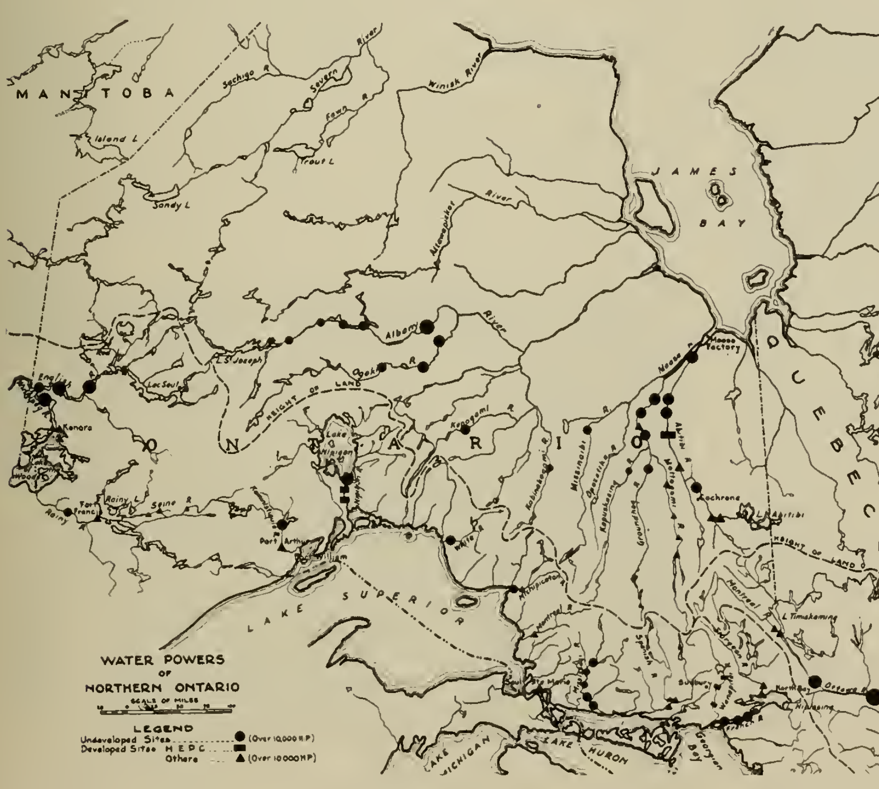


**Fig. 1—Map of Northern Ontario showing Location of Developed and Undeveloped Water Power Sites.**

*Mississagi River*—There are no developments constructed on the Mississagi river, but the potential capacity of this river is 140,000 h.p. which may be developed at reasonable cost in eight sites.

*Spanish River*—There are four developments on the Spanish river with a total capacity of 86,000 h.p., 56,000 h.p. in three plants at Big Eddy, High Falls and Nairn owned by the International Nickel Company, and one at Espanola owned by the Abitibi Power and Paper Company which formerly supplied power to the Espanola mills.

*Wanapitei River*—On the Wanapitei river, a tributary of the French river, there are three developments, operated by the Commission, which supply 60-cycle power to the Sudbury district.

*French River*—The French river flows from lake Nipissing into Georgian Bay and has a potential capacity in three undeveloped sites of 40,000 h.p.

*Sturgeon River*—The Sturgeon river, which flows into lake Nipissing from the north, has two developments at Crystal Falls and Sturgeon Falls, owned by the Abitibi Power and Paper Company, which formerly supplied power to the Sturgeon Falls mills.

### Ottawa River Drainage

No developments have been constructed on the interprovincial section of the Ottawa river between Pembroke and lake Timiskaming, but Ontario's share of the undeveloped power available in this section is 250,000 h.p. A fall of 200 feet exists on this reach, of which 70 feet is above Mattawa, and 130 feet below.

*Montreal River*—The Montreal river flows into lake Timiskaming from the west, and five developments with a total capacity of 32,000 h.p., owned by the Canada Northern Power Company, supply power to the mining areas to the west. There is also a development of 13,000 h.p. on the Matabitchewan, which joins the Montreal near its mouth, also owned by the Canada Northern Power Company. Undeveloped sites totalling 30,000 h.p. are available on the Montreal river.

## HYDRO-ELECTRIC POWER COMMISSION DEVELOPMENTS

### Cameron Falls

The Commission's first venture in Northern Ontario was the construction of a plant on the Nipigon river at Cameron Falls to supply a demand for power in the municipality of Port Arthur, and for pulp and paper mills in the vicinity. Because of the small potential market, consideration was first given to a site on the Kamanistiquia river with a potential capacity of 25,000 h.p., which was a considerably shorter distance from the market. Looking to a major growth in load in the near future, however, it was decided to proceed with the initial stage of the development at Cameron Falls, which site had an ultimate capacity of 75,000 h.p. with regulation of the outflow from Lake Nipigon. Two 12,500-h.p. units were installed in the first stage. Construction of this plant was begun in 1919, and the initial installation went into service in 1921.

The growth in load on the system necessitated the installation of two additional units by 1924, which brought the capacity of the plant up to 50,000 h.p. Almost immediately after the third and fourth units were installed, it was necessary to proceed with the fifth and sixth units, which went into service in 1925. At this time the construction of the Virgin Falls dam at the outlet of Lake Nipigon was completed, which provided practically complete regulation of the flow of the river.

Starting from January 1921 with an initial load of 10,000 h.p., by the end of 1923 the load was approaching the capacity of the first two units. By the end of 1925 the load had reached 50,000 h.p., or the capacity of four units, and by 1929 the load was in excess of the rated capacity of the plant. This phenomenal growth in load was due primarily to the absorption of large blocks of power by the four pulp and paper mills operating in this district.

The development consists essentially of a reinforced concrete headworks and power house on the right bank, and a stop-log sluiceway dam across the river at the crest of Cameron Falls, where formerly a natural drop of 30

Fig. 2—Cameron Falls Development, Nipigon River.

feet occurred. The dam raises the water 45 feet, flooding upstream for a distance of twelve miles, and provides a head of 75 feet. Six auxiliary dams were required to close off low areas in the headwater reach. A short tailrace channel carries the water from the power house to the lower river below the rapids.

A complete reinforced concrete superstructure was constructed over the generator room, headworks and interconnecting supply pipes, and the transformers are installed indoors above the supply pipes, as it was thought advisable at that time to provide complete protection for all operating equipment.

Access to the site was obtained by means of a short railway spur from the Canadian National Railways, which passed close to the river at this point on the opposite bank. The provision of the large headpond with very low velocities permits the formation of an ice cover early in the winter, and no operating difficulties due to ice trouble have been experienced during the fifteen years this plant has been operating.

High tension lines transmit the power to Nipigon on the north shore of lake Superior, and then southwesterly to Port Arthur and Fort William. A recent development has been the construction of a 44-kilovolt transmission line northeast to the Little Long Lac and Sturgeon river mining areas, the present load on this line being approximately 4,000 h.p. A new 110-kilovolt line is now under construction from Cameron Falls to Little Long Lac to meet the growth in load in this district, and to provide better service to the operating mines.

### Alexander

Preliminary construction in connection with the Alexander Development was commenced in 1927, but it was not until 1929 that operations were speeded up to keep pace with the load growth, the plant going into service in 1930. The head at this site is 60 feet, and three 18,000-h.p. units are installed, provision being made for the addition of a fourth unit by the construction of the headworks portion. An earth fill dam, constructed by the semi-hydraulic fill method, was built across the river channel at a turn in the river, and a low concrete spillway section connects the end of the earth dam with the power house which is located on the right bank at tailwater level.

During the construction of the main dam the water was diverted through a channel excavated in rock immediately adjacent to the power house. This diversion channel now carries the water to the power house, and the lower end is blocked off with a concrete plug. There are no regulating sluices installed at this plant, the free spillway being of sufficient length to discharge the flood flow of the river within a range in elevation of five feet.

The generator room superstructure is of brick, the headworks, with the exception of a small area housing the headgate hoists, being left open. An outdoor transformer station is located adjacent to the power house. This is a departure from the layout at Cameron Falls, where the headworks and transformers are housed in.

The Alexander plant is tied into the transmission lines feeding the Port Arthur and Fort William districts. On account of the small area of headpond between Alexander and Cameron Falls, these two plants are required to operate in step, the Alexander plant thus obtaining full advantage of the large headpond at Cameron Falls. The firm power demand on these two plants is now approximately 80,000 h.p., the remaining energy being used for the generation of steam for use in the pulp and paper mills in the Port Arthur district.

### Ogoki Diversion

The diversion of the run-off from 6,000 square miles of the Ogoki river, to the north of Lake Nipigon, which now joins the Albany river and flows into James Bay, has been studied by the Commission for some time. This scheme proposes the construction of a dam on the Ogoki at Waboose Rapids and the diversion of the flow above this point through an artificial channel across the height of land, thence following the valleys of the Little Jackfish river, or Seymour creek, into Lake Nipigon. This diversion would provide an additional flow of 4,000 cubic feet per second to the Great Lakes system, and would increase the dependable capacity of the two plants on the Nipigon by 35,000 h.p. An undeveloped head of 105 feet still remains between Lake Nipigon and Cameron Falls head-

Fig. 3—Alexander Development, Nipigon River. Interior View of Power House.

water, the capacity of this site being 100,000 h.p. with present river flow, and 130,000 h.p. if the Ogoki diversion scheme is consummated.

### Ear Falls Development

The Lac Seul conservation dam, at the outlet of the lake, was constructed in 1928-1929 by joint agreement between the Province of Ontario and the Dominion Government (acting on behalf of the Province of Manitoba) to regulate the flow of the English river for the benefit of the power plants on the Winnipeg river in Manitoba, and to increase the dependable capacity of the undeveloped sites on the English river in Ontario. The area of Lac Seul is 420 square miles, and a 14-foot variation between the maximum and minimum regulated levels gives very nearly complete regulation of the total outflow.

The Howey mine at Red lake was planning the construction of a large mill at this time and required a considerable block of power for their operations. Accordingly, the Ear Falls development was constructed by the Commission at the site of the conservation dam, and a transmission line, about forty miles long, built by the Mining Company into Red lake. The power house is located immediately downstream from the dam, on the north bank of the river, two short 12-foot diameter wood-stave pipes carrying the water from the two end sluices of the dam. One vertical unit, rated at 5,000 h.p. under 36-foot head, was installed, which went into operation early in 1930. This unit has now been operating continuously for over seven years, except for three shutdowns of short duration for inspection purposes, which is believed to establish a record in Canada for continuous operation of one unit.

The plant operates under a head varying from 30 feet to 44 feet, dependent on the levels of Lac Seul and the tail-water, the latter also having an extreme range of 14 feet. An outdoor transformer station is located immediately adjacent to the power house, and the transmission line delivers power to the Howey mine at Red lake, from which point it is distributed to Mackenzie Red Lake and Red Lake Gold Shore mining properties. Contracts have also been executed with several other mines in the district, and negotiations are being carried on with mining companies in the Woman lake district to the east.

For the installation of the first unit the winter freight rate from rail head to Ear Falls was $65 per ton, and the summer rate by water route $12 per ton. The development of the mines in the Red lake district has resulted in a tremendous increase in freight movement from Hudson to and beyond Ear Falls, and these rates have dropped, for the installation of the second unit, to $30 and $7 per ton, respectively.

### Rat Rapids Development

In 1934 the Central Patricia and Pickle Crow mining companies had been carrying along development work in the Pickle Crow area aided by power derived from steam plants using wood for fuel, to the point where the installation of mills was justified, and these companies approached the Commission with a view to obtaining a supply of electric power for their mining and milling requirements at a price which would make the development of their properties attractive. The power from their wood-burning plants was costing approximately $200 per horsepower per annum, and the source of fuel supply was getting farther and farther from the mines. The cost of power from Diesel plants was estimated by the mining companies to be $120 per horsepower, and, in spite of the fact that good power sites were not available within economical transmission distance from the mines, contracts were made with these two companies to supply them with power at an initial figure of $65 per horsepower.

Near the height of land, as in this district, it is unusual to find economical sites for power development as concentrations of head and volume of flow are low. Several sites on the Albany river below Lake St. Joseph were investigated and found to be favourable for larger blocks of power than these two mines appeared to be able to use, as the initial requirement for which the mines were prepared to contract was in the neighbourhood of 1,000 h.p. Accordingly, the site at the outlet of Lake St. Joseph, where a head of from 10 to 16 feet was available, with an ultimate potential capacity of about 3,000 h.p., was selected. One unit was installed with a capacity of from 1,000 to 1,500 h.p.

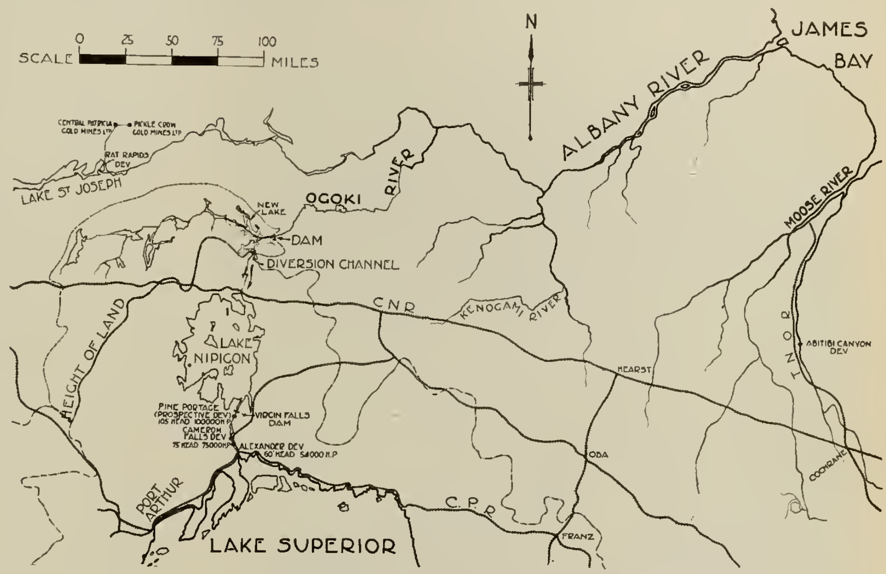


**Fig. 4—Map showing proposed Diversion of Portion of Ogoki River into Lake Superior.**

In order to keep the initial cost of the development as low as possible, timber crib dams were constructed at the northerly, or Rat channel, outlet, and also at the southerly, or Cedars channel, outlet, some five miles south of the Rat channel. The power house was built at the northerly outlet and contains one horizontal turbine with four runners, direct-connected to a horizontal type generator. This unit complete — turbine and generator — was available in storage at the Commission's Calabogie plant on the Madawaska river, and because of its size, being rated at 3,000 h.p. under 27-foot head, it was thought to be particularly suited to supply a mining load of the type expected. New runners were required to adapt the unit to the reduced head under which it would operate. This plant was built in 1934-1935, and went into operation in March 1935, a transmission line, twenty-five miles long, having been built from the power house to the Central Patricia mine and then on to the Pickle Crow.

Transportation costs from rail head to the site played an important part in the design of the structures and the materials used. In the construction of the first stage of the development, the total transportation costs from rail head to the site on all items amounted to 20 per cent of the total cost of the work, in spite of the fact that timber was adopted for the construction of the dams and other structures wherever possible, and that the minimum amount of concrete was used in the power house. The freight rate by winter road amounted to $60 per ton, and practically all of the material was taken in in this manner, the transportation cost on cement alone amounting to about $18 per cubic yard.

Unlike Ear Falls, where a considerable amount of local timber suitable for construction was found, at Rat Rapids the local timber was of smaller diameter, and it was necessary to scour the district to find a sufficient amount for the construction of the timber crib dams. A good stand of red pine was discovered about forty miles up the lake, and arrangements were made with the provincial authorities to obtain sufficient of this for the structural timber requirements. If B.C. fir had been used, the transportation costs alone from rail head would have been $100 per thousand. Because of these high transportation costs, the construction of rock fill crib dams using local timber was decided upon, as the rock fill was readily obtainable. While timber crib dams in such localities cost considerably less than concrete dams, their life is only from ten to fifteen years, but, considering the probable life of the mines, their construction is amply justified.

**Fig. 5—Ear Falls Development. Showing Lac Seul Conservation Dam, Power House and Transmission Line to Red Lake.**

The load on the Rat Rapids plant increased rapidly to the point where an additional unit was required, and a second unit, rated at 1,750 h.p., was installed, which went into operation in October 1936. At the present time the load on this plant is 2,100 h.p.

For the installation of the second unit, the Root river transportation route had been constructed, and practically all the material for the installation of this unit was taken over the water route, the rate from rail head to Rat Rapids being $25 per ton, as compared with $60 per ton by winter haul for the initial development.

The synchronization of mining hoist and compressor motor loads results in load swings at the power house equal to 50 per cent of the total load at times, these swings being at the rate of 15 to 25 per minute, and it will be realized this is a very severe operating requirement for a hydro-electric plant, particularly with only one unit installed. This difficulty has been remedied somewhat by the installation of the second unit, which furnishes additional flywheel effect.

### Wanapitei River Plants

In 1929 the provincial government acquired three plants on the Wanapitei river, formerly owned by the Wahnapitae Power Company, which were supplying 60-cycle power in the Sudbury district. These three plants have a normal capacity of 16,500 h.p. A regulating dam at the outlet of Wanapitei lake had been partially constructed by the Company when these plants were acquired, and this dam was completed by the Commission in 1930. This dam gives nearly complete regulation of the flow of the river and enables the full rated output of the plants to be obtained. The present load on these plants is over 15,000 h.p., approximately one-third going to the Falconbridge Nickel Company, one-third to the International Nickel Company, and one-third to the City of Sudbury. The International Nickel Company and the Falconbridge Nickel Company are also taking a considerable amount of 25-cycle power from the Abitibi Canyon plant.

### Abitibi Canyon

Construction of a large hydro-electric power development on the Abitibi river at the Canyon was undertaken in 1930 by the Ontario Power Service Corporation, a subsidiary of the Abitibi Power and Paper Company. The work was well on the way to completion when the company met with financial difficulties, and went into liquidation. The Ontario Power Service Corporation had contracts with the Commission and with the Abitibi Company for large blocks of power. In 1932 the provincial government decided to buy out the assets of the Ontario Power Service Corporation and complete the development, in order to obtain an ample supply of power for the mines in northern Ontario.

A concrete, gravity-type dam having a maximum height of 290 feet, was constructed across the gorge of the river, flooding back twenty-four miles to the Abitibi Company's Island Falls plant, and making available at this site a head of 240 feet. The power house, housing five 25-cycle units rated at 55,000 h.p. each, is located immediately downstream from the dam in the middle of the river channel, the water supply being obtained through a headworks structure at the top of the dam and steel penstocks eighteen feet in diameter. A tailrace was excavated in the river bed 1,800 feet long to the slack water reach downstream. Five 45-foot sluice gates capable of discharging a maximum flow of 150,000 cubic feet per second were installed on the right, or east, bank adjacent to the power house, and a training wall 3,000 feet long was built between this high water channel and the river, in order to protect the power house and tailrace channel. Complete unwatering of the site during construction of the dam and power house was obtained by the provision of two diversion tunnels on the west side of the river.

The transformers are located on the power house roof, and the high tension switches behind the headworks at the upper level. Steel headgates are provided for unwatering the units and a specially constructed unloading crane was installed on the west bank to handle equipment from the railway spur at this point into the power house.

Two steel tower transmission lines were built to Hunta, just west of Cochrane on the Canadian National Railway, and one from Hunta to Sudbury to supply 25-cycle power to the Falconbridge and International Nickel Companies. Lines were also built from Hunta to Smooth Rock Falls and from Hunta to Iroquois Falls to supply power to the Abitibi Company's mills at these points. From Iroquois Falls a line was built to Kirkland lake to supply the mines in this vicinity, the line from Hunta to Sudbury passing through Timmins supplies the mines in the Porcupine area. A contract was made with the Canada Northern Power Company wherein the Company agreed to take from the Commission power for all their growth in load for a ten-year period.

The Canyon plant started operation in May 1933 with an initial load of 15,000 h.p. The growth in load since that time has been very rapid, and at the present time the primary load on this system is 75,000 h.p. It is estimated that within the present year the primary load will have reached 100,000 h.p., all of which will be absorbed by the mines in the three mining districts served. At present the surplus capacity is being disposed of to the Abitibi Company for steam production at its mills, but this service will be reduced as the primary load increases.

The outflow from Abitibi lake is controlled by the Abitibi Company's power plant at Twin Falls and the six-foot range available on this lake provides sufficient water for the full rated output of the large mill at Iroquois Falls (which is capable of producing 600 tons of newsprint per day), the necessary power being obtained from the plants at Twin Falls, Iroquois Falls and Island Falls.

The capacity of the Canyon site may be increased by approximately 40,000 h.p. with more complete regulation of the flow of the river by the construction of a storage dam on the Frederick House river with 300,000 acre feet capacity. This river joins the Abitibi just upstream from the Island Falls plant. The installation of this storage was a part of the general scheme of the development of the Canyon site proposed by the Ontario Power Service Corporation, and consideration is being given to it by the Commission and the Government at the present time.

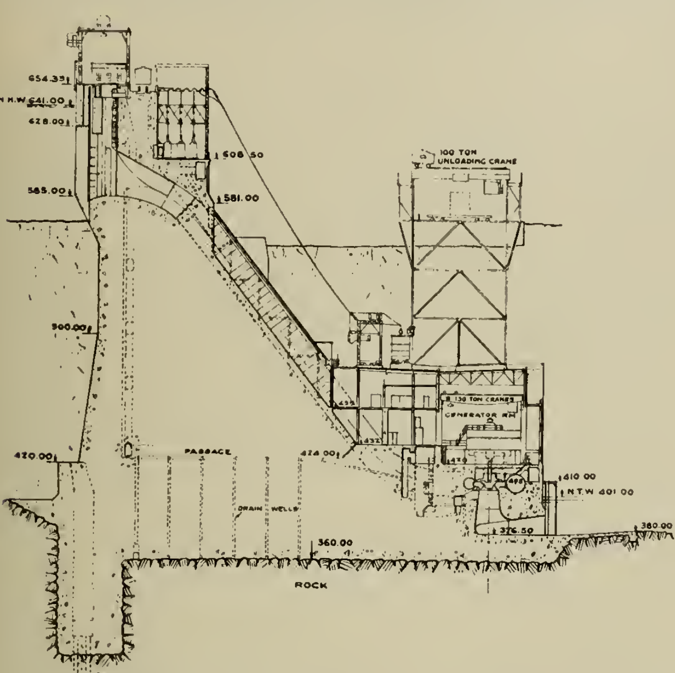


**Fig. 6—Abitibi Canyon. Cross Section through Main Dam and Power House.**

## DISTRIBUTION OF POWER

### The Pulp and Paper Industry

Reviewing the foregoing, there are power plants on the Winnipeg river supplying power to the mills at Kenora, and plants on the Seine and Rainy rivers supplying power to the mills at Fort Frances. The two Nipigon river plants and the Kamanistiquia river plant supply power to the mills in the Port Arthur and Fort William districts. The Smoky Falls plant on the Mattagami river supplies power to the Kapuskasing mills, and the three plants on the Abitibi river supply power to the Abitibi Company's mill at Iroquois Falls. These are the five large producing areas in northern Ontario.

The modern pulp and paper mill requires about 100 h.p. per ton of daily output. Large power reserves in undeveloped sites in proximity to the mills are available, and the capacity of these undeveloped sites is sufficiently large to at least double the present output of the companies now operating in Ontario.

### The Mining Industry

For mining and milling a producing mine requires from 2½ to 5 h.p. per ton of daily output. The present requirements of the mines in the Red lake district are being taken care of by the development at Ear Falls, with one 5,000-h.p. unit installed, and an additional 5,000-h.p. unit being added at the present time, the ultimate capacity of this site being 25,000 h.p. Other sites of large capacity are available farther down the river should the mines require more power than the Ear Falls site could provide.

The Rat Rapids development, with the present installation of 3,000 h.p., provides for the present requirements of the producing mines in the Pickle Crow area, and additional sites are available on the Albany river downstream from Rat Rapids, within economical transmission distance of these mines.

There are a number of promising mining properties operating in the region midway between the Pickle Crow and the Red lake areas, in the vicinity of Woman lake and the Cat river. If these mines require hydro-electric power, a transmission line from Ear Falls could be constructed. This area is near the height of land between the northerly and the southerly drainage, and also is the divide between the easterly and westerly drainage. The country is flat and no power sites of any appreciable capacity exist in the immediate vicinity.

The mines in the Little Long Lac and Sturgeon river areas are at present supplied from the Cameron Falls plant on the Nipigon river, and ample power is available from this river for any possible expansion for years to come.

The Porcupine and Kirkland lake mining areas are the major gold producers in Ontario, and receive their power supply from the Canada Northern Power Company, with plants on the Montreal and Mattagami rivers, and from the Commission's Canyon plant on the Abitibi. There is a considerable reserve of power still available from the Canyon plant to supply growth in load in these areas, and there are additional undeveloped sites of large capacity in the vicinity.

The Canyon plant also supplies 25-cycle power to the International Nickel Company and the Falconbridge Nickel Company in the Sudbury district. These companies, which are understood to be the largest producers of nickel in the world, also obtain 60-cycle power from the three Wanapitei river plants. The International Nickel Company also owns and operates three plants on the Spanish river which supply power to their smelters. Future power supply for this district, in smaller amounts, is available from three sources within short transmission distance, the Spanish, Sturgeon and French rivers. Larger blocks of power would be available from developments on the Mississagi or the Upper Ottawa river, as well as from the Canyon plant.

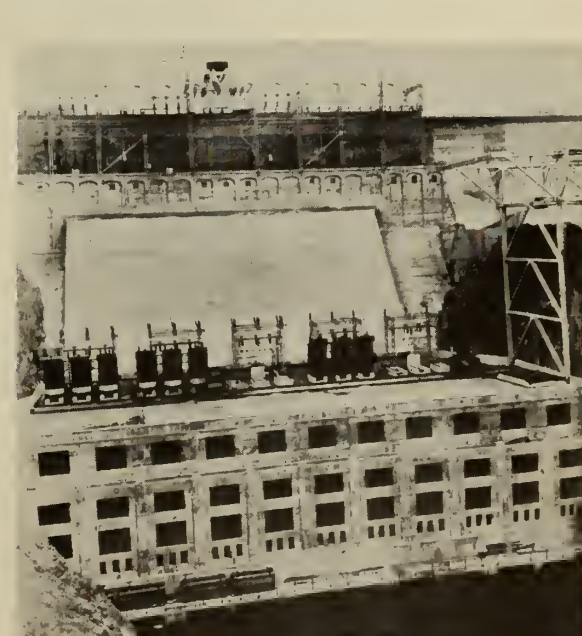

**Fig. 7—Abitibi Canyon. General View of Dam and Power House.**

MINING CONTRACTS

The rapid expansion of the mining industry in northern Ontario has been briefly outlined, and present indications are that this rapid growth will continue. The rates at which power can be sold, and the terms of the contract under which delivery is made, are of prime importance in the development of the mining industry. Two essentials must be observed—safeguarding of the investment of public funds, and the adoption of a rate schedule enabling the purchase of power to be made at reasonable cost to operating companies, particularly in the early stages of their development. The Commission's mining contracts fulfil these two conditions. The standard contract requires the customer to provide a bond sufficient to cover the immediate investment in transmission costs to serve their property, and to cover three months' power bills. In new mining districts largely in the development stage, such as the Red lake and Pickle Crow areas, the customers may be required to bear the entire cost of the transmission line.

Fig. 8—Abitibi Canyon. Interior View of Power House.

An initial rate for power is set in some instances, for isolated properties, sufficient to write off the major portion of the cost of the development in from five to ten years' time, at the end of which period the rate per horsepower would be reduced if the mine were still operating. The term of these contracts is for ten years, or the mining life of the property, whichever is the shorter.

If at any time during the continuance of the contract a fault in the customer's ore bodies makes necessary extensive exploration work to locate future working ore bodies, and thereby makes necessary a substantial or complete shutdown of the customer's mill, the customer is entitled to special consideration and may be relieved of payment for 75 per cent of the contract amount of power during the continuation of this fault period. If within three years of the commencement date of the contract the customer abandons all mining operations, the minimum bill called for in the contract is paid for two months and the contract may then be cancelled without further penalty. Abandonment after three years of operation may be made without any penalty whatsoever.

Power is paid for on the basis of the highest ten-minute average or integrated peak created during each month at 85 per cent load factor and 85 per cent power factor. Penalties are required for loads established below 85 per cent power factor and above 85 per cent load factor. Prevailing rates in the Abitibi district for high tension power are $32.50 per horsepower for demands up to 5,000 h.p., $22.50 for demands between 5,000 and 10,000 h.p., and $17.50 for demands between 10,000 and 20,000 h.p. In the Little Long Lac, Sturgeon river and Red lake areas prevailing rates are $35 per horsepower per annum. In districts where special developments are required to serve specific mining properties, such as the Pickle Crow and Central Patricia mines, special rates are adopted.

The entire rate schedule of the Commission for all mining districts has been built up on the basis of providing an amortization fund to retire all capital investment in connection with mining properties within a reasonable time, considering the probable mining life of the various properties to which power is being supplied. The rate is also based on the collection of sufficient revenue to meet all operating and administration costs, as well as all fixed charges, including interest and the amortization fund mentioned above.

The Commission, with the generation of over 325,000 h.p. last December, is now the largest producer of power in northern Ontario. Its plants on the Nipigon river have operated since 1921 primarily on pulp and paper mill load. At the present time it is supplying power to mining properties to a total of 95,000 h.p., and this load has been built up from zero in the last six years. In supplying power for mining purposes in northern Ontario, the endeavour of the Commission has been to give a high standard of service commensurate with the load to be served, keeping in mind the advisability of giving power at as low a cost as possible in initial stages of development. With the exception of the Nipigon river plants, all of the Commission's developments in northern Ontario are in connection with the mining industry, and the generating plants are owned by the Provincial Government and operated for them by the Commission.

The rapid growth in the pulp and paper industry between 1915 and 1930 was made possible, to a large extent, by the availability of large amounts of low cost power. The output of the mills was curtailed somewhat during the ensuing four years, but the 1936 output exceeded that of any preceding year. At the present time all of the larger mills are operating at or near capacity, with ample power reserves, and if future markets demand the construction of additions to these mills, suitable undeveloped power sites are available to supply additional power.

Mining in Ontario assumed major proportions in 1908 when the silver mines in the Cobalt area came into production. Then about 1916 the big gold producers at Porcupine and Kirkland lake became active, and from that time until 1930 the mining industry in Ontario, particularly gold and nickel producers, expanded rapidly and became a major industry. The availability of ample supplies of power materially assisted in this development. In the last two years, due primarily to the higher price of gold and base metals, output was speeded up, new mines came into production, and large amounts of power were absorbed. Moreover, it is the opinion of mining authorities that this speeding up will continue for a number of years, and, if so, there are large undeveloped sources of power which can be made available for the industry as required. Thirty years ago most people thought of northern Ontario as a vast unproductive wilderness. Present knowledge indicates that it is destined to play a very important part in the future prosperity of our province.

# Speech and Music and Their Relation to Transmission Problems

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The development and growth of radio broadcasting has aroused a widespread interest in the transmission of speech and music over long distances, both as radio waves and over communication lines. Although before radio broadcasting had become general, nearly everyone was familiar with the telephone and its transmission of speech, and in a few cases music, it was looked upon as an ordinary feature of daily life with very little thought being given to its performance. On the other hand, in the case of radio broadcasting, in which the quality and volume of the received speech and music are somewhat within the control of the person at the receiving end, the problems incident to the transmission of speech and music have become of interest to many persons.

Because of this general interest, it seems timely to present some of the factors underlying the proper transmission of speech and music.

In the telephone business the proper transmission of speech is the primary function, as the subscriber wishes to communicate with others easily and understandably. For such a transmission service, the main requirement is intelligibility, although in recent years improvements in the art have gone beyond just the provision of intelligibility. However, in the transmission of speech or music for broadcasting purposes the entertainment requirements are such that it is important that their naturalness be preserved.

The telephone engineer has become vitally interested in the problems associated with providing such a high grade service because except under special and unusual conditions all connections between studios or sources of broadcasting material and transmitter stations are by means of land lines rather than radio channels. Thus the telephone engineer has had a problem which has required solution somewhat as follows:—

(1) The determination of the physical nature of the sounds to be transmitted from one place to another; or in other words the obtaining of an understanding of the physical nature of speech and music.

(2) The determination of the reactions of any transmission system upon the electrical waves produced by these sounds.

The solution of this problem makes it possible to predict the characteristics of the thing which is delivered to the receiver, be it a telephone set or radio system. To this information, however, must be added a knowledge of the effects of any such distortions as may occur upon the interpretation given by the ear.

It is the purpose of this paper to discuss the two phases of the problem outlined above.

First, then, consider the mechanism of the production of speech. The lungs, by their bellows-like action, supply streams of air which pass through the vocal passages, the vocal chords, the mouth, the lips and the cavities of the nose and throat. These by variations in their adjustments impress on the air streams from the lungs variations which are heard as speech sounds. The diagram in Fig. 1 shows a longitudinal section of a human head giving the relative positions of these various organs. The vocal chords, which are a pair of muscular ledges on either side of the larynx forming a straight slit, are set in vibration by streams of air from the lungs, and thus create sound waves which are conducted through and modified by the vocal passages. The passages impress upon the air vibrations resonant characteristics which determine the character of the resulting speech. The so-called voiced sounds, including all the vowel and consonant sounds except p, t, ch, k, f, s, th (thin) and sh are produced in this manner. The production of the last mentioned speech sounds does not involve the vocal chords but is a matter of the setting up of vibrations by the mouth itself.

The voiced sounds may be divided into two classes according to their method of production. The continuants are produced by a continuous flow of air past the vocal chords, as for example, the vowel sounds. The stops are produced by a sudden stoppage in the air passage by the lips, or tongue, as for example, b, d.

It will also be noticed from Fig. 1 that there are two variable resounding cavities through which the air vibrations from the vocal chords pass, the throat and the mouth. These two resounding cavities, then, cause the continuants to have magnified frequencies in two principal regions. For example as is shown in Fig. 2, the sound ah sung d, has the two principal frequency ranges at about 200 and 1,000 cycles and it is largely these particular regions of resonance that distinguish it from other sounds.

Use of this knowledge has been made in aiding those unfortunates who have had to undergo the surgical operation

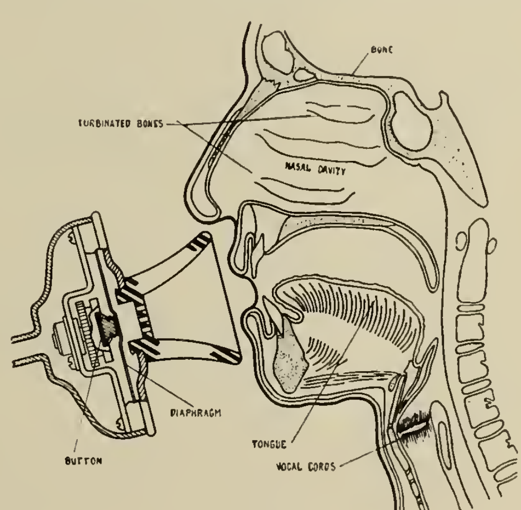



**Fig. 1**

known as tracheotomy, which operation leaves no connection between the lungs and the mouth. When a patient recovers from such an operation, the process of breathing is carried on by drawing the air in and out through a small opening in the neck, consequently, the patient can make no vocal sounds. If an attachment is made to the opening of the windpipe so that the patient can blow a whistle such as is used in toy balloons and the sound is directed into the corner of the mouth, the patient can learn to talk again. Such a device, now known as the artificial larynx, has been developed and is being used by a number of such patients. The quality at present, is, of course, somewhat different from that of the human voice but the speech is understandable and it is hoped that through refinement and further investigation the naturalness of the speech sound thus produced will be improved.

The sung sounds are produced in much the same manner as the spoken sounds. One difference of course lies in the greater emphasis placed on the continuants.

Musical sounds are characterized by being sustained at definite pitches for comparatively long times and by having the changes in pitch take place in definite steps known as musical intervals—thirds, fifths, octaves, etc. Musical tones are produced mainly by two physical mechanisms besides the voice: vibrating strings as with the violin, harp, piano, etc., and vibrating air columns as by the pipe organ, flute, horns, etc.

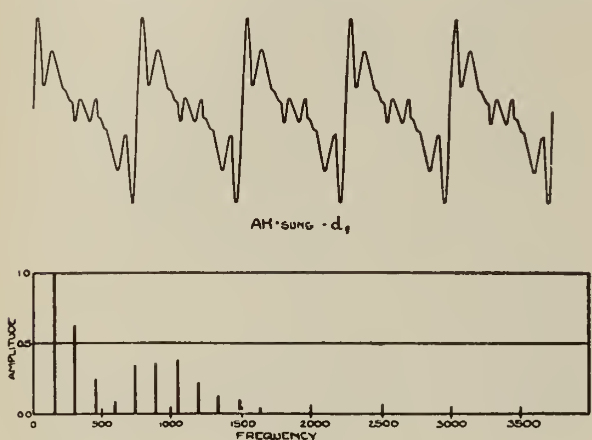


Fig. 2

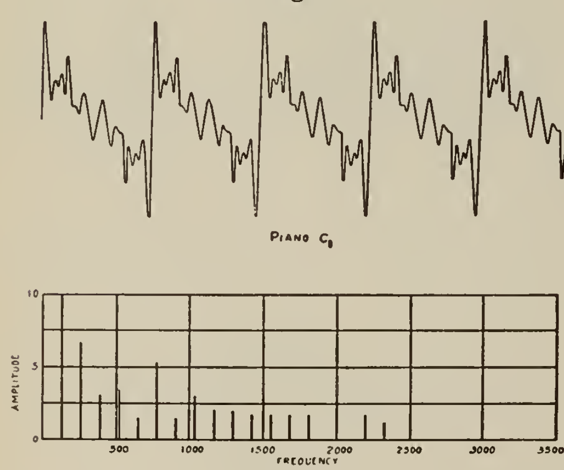


Fig. 3

A single musical note contains more than one frequency of vibration and is therefore a complex tone. For most musical tones the component frequencies are multiples of a fundamental which is the lowest frequency present in the tone, and which is the frequency determining the pitch of the tone, which in turn is that subjective characteristic by means of which the listener is enabled to locate the position of the tone on a musical scale. The richness and quality of musical tones are due to the abundance and relative amplitudes or energies of the harmonic components and, in general, a listener is enabled to recognize the kind of musical instrument producing the sound because of the differences in the numbers and relative amplitudes of the harmonics. This characteristic is usually referred to as the timbre of the musical tone.

In Figs. 2, 3, 4, 5 and 6 are shown some wave forms of musical sounds produced by the voice, piano, violin, and cello organ pipe and also the relative amplitudes of the fundamental and harmonics. For each of the examples shown except for the cello organ pipe it will be noted that the fundamental frequency corresponds to the assigned pitch and that this frequency has the greatest amplitude. In the case of the cello organ pipe, however, the frequency of greatest amplitude is the third harmonic and this corresponds to the assigned pitch. It is also interesting to note that the voice, the cello organ pipe and the piano in its lower registers have numbers of relatively intense harmonics while the violin and the piano in its upper ranges have few harmonics of relatively weak intensity. These differences explain the purer and sweeter tones of the violin and upper registers of the piano.

In the case of pipe organ music, the principal charm is contained in the strong bass notes whose pitches lie in the range below about 100 cycles. Although the older types of circuits used in radio broadcast transmission were somewhat inefficient at these low frequencies the principal offender was usually the loud speaking receiver of the radio set. Latterly both the circuits and receivers have been improved within this range.

From what has been reviewed it will be realized that a great deal is required of any transmitting medium between concert hall or studio and receiver to assure of satisfactory reception at the receiver of the transmitted sounds.

One of these requirements is that the system must be capable of transmitting a wide range of frequencies without changing their relative intensities. Figure 7 gives some data relative to the frequency ranges required for musical instruments and the voice. This figure indicates that there should be transmitted a range of from near 35 cycles to near 15,000 cycles. Tests have shown, however, that if within the range of from 35 to 8,000 cycles the relative intensities are maintained the results obtained are very pleasing.

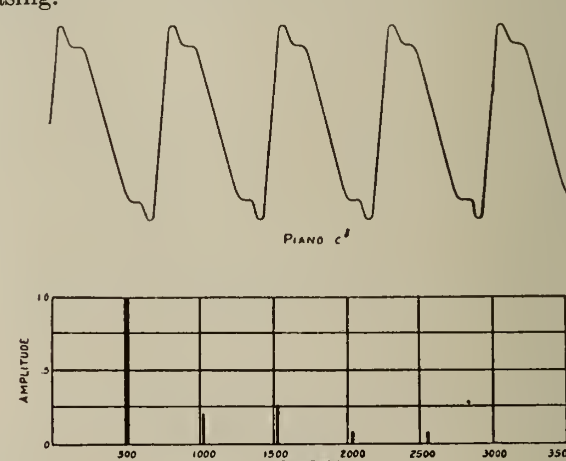


Fig. 4

Over wire lines and through amplifying equipment the time of transmission differs for the various frequencies being transmitted. Tests have indicated that in the range of from 5,000 to 8,000 cycles the time of transmission should not differ from that at 1,000 cycles by more than 5 to 10 milliseconds and that as between 50 and 1,000 cycles this difference should not be more than 75 milliseconds. These maximum differences require that amplifying equipment be very carefully designed for very small differences and that the differences inherent in transmission facilities be corrected by delay equalizing networks.

There must be within the transmission system no production of spurious frequencies except in minute quantities. Consequently, amplifiers must have extremely small modulation effects and in any magnetic circuits the ratio of flux density to ampere turns must be substantially constant.

The human ear can hear volume ranges as shown in Fig. 8, in which the ordinates indicate decibels* relative to a reference energy of $10^{-16}$ watts per square centimeter and the abscissae indicate frequency. At 1,000 cycles the lowest intensity that the average ear can hear is 0 db. or $10^{-16}$ watts per sq. cm. and on the other hand the intensity at which the average ear begins to have a sensation of

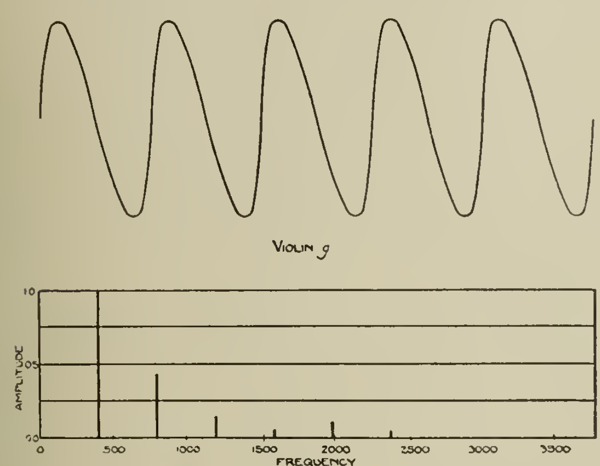


**Fig. 5**

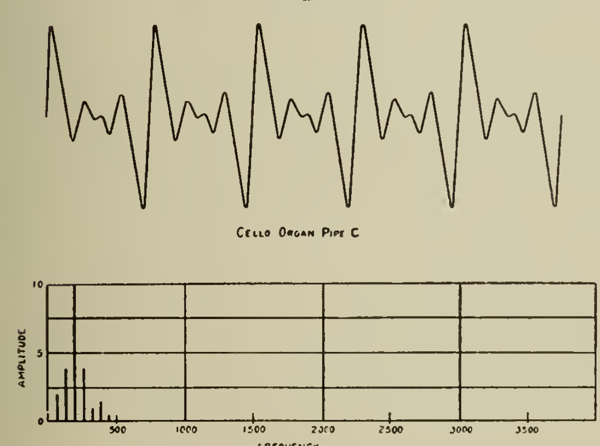


**Fig. 6**

feeling rather than hearing is 120 db. greater or $10^{-4}$ watts per sq. cm. There is produced at the ear of a favourably positioned listener to a symphonic orchestra an intensity range of about 70 db. which is located in the hearing range as shown in Fig. 8. Allowing for a 10 db. range at the lower intensities for the masking effects in a concert hall of audience and similar noises there remains an intensity range that could be appreciated by an audience of about 100 db. which is 30 db. greater than that available at present from a large symphony orchestra. For rooms in residences, due largely to room noise masking the quieter passages or undesirably great intensities during loud passages it has been found that it is not desirable to exceed a maximum range of about 40 db. In addition in radio reception the presence of static noise may raise the lower level of the range, thus narrowing it. Any system for the transmission of radio programme material should therefore be capable of transmitting a range of volumes of about 40 db. without introducing appreciable amounts of noise during the intervals of transmission of low volume or causing distortion during intervals of high volume.

From the above somewhat sketchily presented information it therefore will be realized that any system for the high grade transmission of speech and music must be carefully designed, constructed and maintained.

*See Appendix I.

## Appendix I

*Definition of the Decibel*

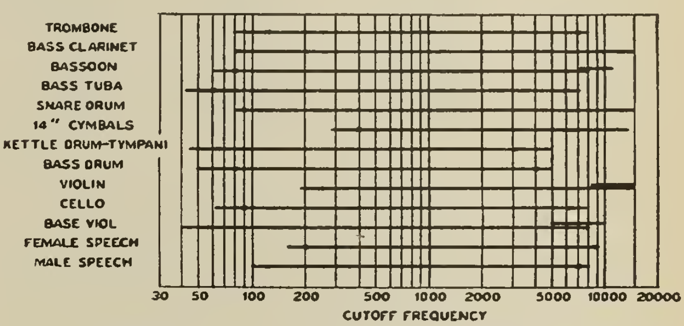
The international unit of measurement of communication transmission is the bel, and one derived practical unit much used on the North American continent, is the decibel, or db., which is one tenth of a bel. This unit relates two quantities of power through the common logarithm of their ratio. For example a power ratio of 10 or 1/10 represents 10 db, gain or loss, a power ratio of 100 or 1/100 represents 20 db., etc. For a power ratio of 45 the gain is:

$$10 \log 45 = 10 \times 1.653 = 16.53 \text{ db.}$$

For the same power ratio the loss is:

$$10 \log 1/45 = 10 \log 0.0222 = 10 (\bar{2}.347) = -10 \times 1.653 = -16.53$$

By the use of decibels rather than power ratios the calculation of transmission losses or gains becomes one of addition and subtraction rather than multiplication and division.



-Summary of important ranges required for different instruments.

**Fig. 7**

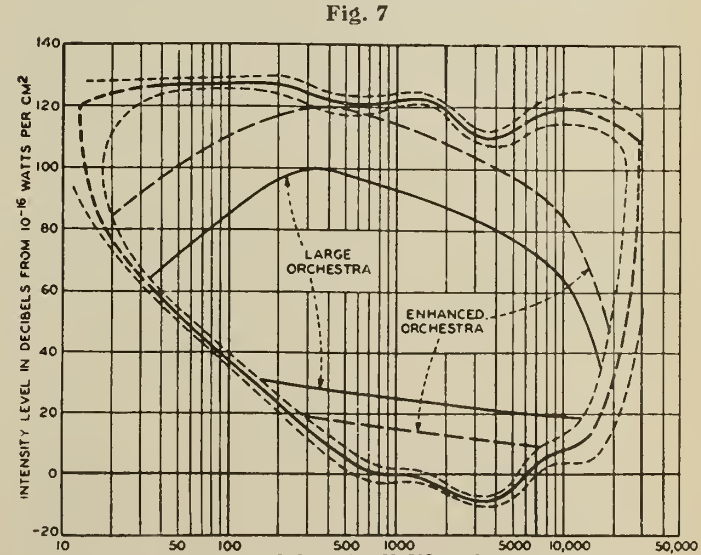


**Fig. 8**

Since decibels refer to relative powers, zero db. is only a power ratio of unity and for the designation of absolute powers a reference power must be used. The reference power level referred to in this paper is a power of 0.006 watts. Then, for example, −45 db. volume level is 45 db. level below 6 milliwatts.

$$\text{Then power ratio} = \text{antilog } 45/10 = 31630$$

$$\text{Therefore—45 db volume level is a power of } 0.006/31630 = 1.9 \times 10^{-7} = 0.00000019 \text{ watts}$$

THE
# ENGINEERING JOURNAL
THE JOURNAL OF
THE ENGINEERING INSTITUTE
OF CANADA



VOLUME XX MARCH, 1937 No. 3

## The Vote on By-law Revisions

The proposals for the revision of The Institute's By-laws which will shortly be put before the corporate membership for approval by ballot are not mere verbal amendments affecting minor points of procedure. They contemplate an important change in The Institute's course, a broadening of the road along which it is progressing, and the establishment of closer relations with the Provincial Associations of Professional Engineers. For this purpose they invite the members of all these associations to join with The Institute membership so as to constitute a Dominion-wide organization.

The report of the annual general meeting at which these matters were debated, is published in this issue of The Journal. It indicates that the proposals of the Committee on Consolidation were approved by the members present. The Plenary Meeting of Council had previously approved them, with some suggested modifications, and they have been endorsed by a large number of the Branch Executive Committees. It appears, however, that the proposed revisions are not in accord with the views of some members, who feel that the emphasis laid on the legal organization of the profession tends to divert attention from the original objects with which The Engineering Institute of Canada are formed, based on the interchange and dissemination of professional knowledge. To these members the control and organization of the profession under legal enactments does not seem so important as the technical and service activities of a voluntary engineering society. In this column it would not be proper to state the arguments advanced by the two schools of thought, or even to attempt to summarize them. That is the duty of the committees appointed by the chairman of the annual general meeting to prepare brief statements of the arguments for and against the proposals, which will be placed in the hands of each corporate member with his ballot paper.

An assembly like the annual general meeting affords an excellent opportunity for debate, but the majority opinion on any question expressed at a meeting of one or two hundred members is not necessarily that of the three thousand corporate members who have the right to record their votes on ballot. The result of the ballot which is now in preparation, can only reflect the real majority opinion of the membership *if all will take the trouble to vote.*

The proceedings of the Committee on Consolidation have been clearly placed before the membership by monthly reports in The Journal. The views of councillors, as given during the debates of the Plenary Meeting of Council, have also been reported at length, and the arguments advanced at the annual general meeting are given in this issue of The Journal. In the case of proposals so vitally affecting the future of The Institute it is the duty of every member who has the interests of his Institute at heart to study these reports and papers, particularly the summaries of pro and con arguments which will accompany the ballot. He must then record his vote if the result of the ballot is really to represent the voice of the corporate membership of The Institute.

## Coming Meetings with Sister Societies

The Council of The Institute has received with great appreciation, and has gladly accepted, invitations to participate this year in the activities of two of the Founder Societies of the United States, namely, the American Society of Mechanical Engineers, and the American Society of Civil Engineers. Our members are asked to note the dates and places of the following meetings and to make arrangements to attend them.

During the week of May 17th, 1937, the American Society of Mechanical Engineers is holding its Semi-Annual Meeting at the Hotel Statler, Detroit, Michigan, and its Council has invited the members of The Institute to take part in the technical and social events of the meeting. It will be remembered that last year the Society was good enough to extend the same invitation in respect to its Fall Meeting at Niagara Falls, N.Y. Many of our Ontario members attended and received a most hearty welcome.

The Detroit meeting will include a series of six general sessions, which will be held on the mornings and evenings of Tuesday, Wednesday and Thursday, May 18th, 19th and 20th. The first of these sessions deals with the contribution of automotive engineering to other fields. Mr. C. F. Hirshfeld's address on this subject should awaken engineers to the possibility of adopting in their own work the successful features of the technique of the automotive industry. The key note for the next general session will be improved methods of fabrication and Mr. William S. Knudsen of the General Motors Corp. will be one of the speakers; the third will have as its topic "Lightweight Highspeed Trains" and will be sponsored by the Railroad Division. E. G. Budd, of the company which built the "Zephyr," will speak on this subject. The fourth general session, sponsored jointly by the A.S.M.E. Management Division and the Society of Automotive Engineers, will deal with management and mass production methods. Mr. K. T. Keller, president of Chrysler Corp., and W. J. Cameron of the Ford Motor Co. will address the meeting. The fifth general session, on steel and its application, will be sponsored by the A.S.M.E. Iron and Steel Division, and the concluding summary of the implications of the week's programme will be delivered by Willard T. Chevalier, vice-president of Engineering News-Record.

In addition to the programme outlined above, technical sessions and tours will be held on Tuesday, Wednesday and Thursday afternoons, for which papers will be contributed by the A.S.M.E. Professional Divisions.

There will be excursion trips to the many points in and near Detroit which are of interest to engineers, and during the proceedings the Calvin W. Rice Memorial Lecture will be delivered. Detailed programmes of this meeting are not yet available, but the above outline will sufficiently indicate the interest and importance of the meeting.

At the invitation of the Board of Direction of the American Society of Civil Engineers a joint meeting of The Engineering Institute of Canada and the Society will be held in Boston, Massachusetts, on Wednesday, Thursday and Friday, October 6th, 7th and 8th, 1937. The Institute Council, on receiving the invitation from the American Society of Civil Engineers, appointed Past-Presidents Fairbairn, Shearwood and Cleveland to act as a committee to confer with a like committee of the Society, and the plans for the meeting are being worked out jointly in this way.

It is proposed to devote one of the technical sessions entirely to papers contributed by members of The Engineering Institute of Canada on Canadian engineering matters. The other sessions will be arranged by the technical divisions of the American Society of Civil Engineers, and a particularly interesting feature will be the work of the new division on Soil Mechanics and Foundations.

As regards entertainment and visits to engineering works, those members who have had the privilege of attending A.S.C.E. meetings need no assurance as to the excellence of the arrangements that will be made. The Boston meeting will be particularly attractive to E.I.C. members as offering an opportunity for the renewal of the happy relations developed in July 1934 when our Western Professional Meeting was held in Vancouver concurrently with the Annual Convention of The American Society of Civil Engineers. The joint meeting planned for October will, it is hoped, be largely attended by Institute members, particularly from the east. The time selected is favourable for travelling by road or rail, and the attractions of Boston as a meeting place are undeniable.

Detailed programmes of the meetings will be published in The Journal as soon as available.

## Past-Presidents' Prize 1936-1937

The subject prescribed by Council for this competition for the prize year July 1st, 1936 to June 30th, 1937, is **"The Need of the Engineer's Participation in Public Affairs."**

The rules governing the award of the prize are as follows:—

The prize shall consist of a cash donation of the amount of one hundred dollars, or the winner may select books or instruments of not more than that value when suitably bound and printed, or engraved as the case may be.

The prize shall be awarded for the best contribution submitted to the Council of The Institute by a member of The Institute of any grade on a subject to be selected and announced by Council at the beginning of the prize year, which shall be July 1st to June thirtieth.

The papers entered for the competition shall be judged by a committee of five, to be called the Past-Presidents' Prize Committee, which shall be appointed by the Council as soon after the Annual Meeting of The Institute as practicable. Members and Honorary Members only shall be eligible to act on this Committee.

It shall be within the discretion of the Committee to refuse an award if they consider no paper of sufficient merit.

All papers eligible for the competition must be the bona fide work of the contributors and must not have been made public before submission to The Institute.

All papers to be entered for the competition must be received **not later than June 30th, 1937,** by the General Secretary of The Institute, either direct from the author or through a local Branch.

SEMICENTENNIAL 1887 THE ENGINEERING INSTITUTE OF CANADA FOUNDED 1887 1937 JUNE 15-18 1937

## Semicentennial Committee

| | |
|---|---|
| A. Cousineau, A.M.E.I.C. | R. H. Findlay, M.E.I.C. |
| R. L. Dobbin, M.E.I.C. | F. S. B. Heward, A.M.E.I.C. |
| J. M. Fairbairn, A.M.E.I.C. | J. L. Busfield, M.E.I.C., Chairman |

| | |
|---|---|
| OTTAWA BRANCH | QUEBEC BRANCH |
| Alan K. Hay, A.M.E.C. | H. Cimon, M.E.I.C. |

TORONTO BRANCH
C. E. Sisson, M.E.I.C.

### VISITORS

Recent advices are to the effect that the following names may be added to the list of "prominent visitors"—

Brigadier General Magnus Mowat, C.B.E., F.R.S.E., etc., representing The Institution of Mechanical Engineers.

James H. Herron, M.Am.Soc.M.E., representing the American Society of Mechanical Engineers.

H. V. Potter, representing the Society of Chemical Industry.

A. C. Gardner, F.R.S.E., representing the Institution of Engineers and Shipbuilders in Scotland.

### SMOKING CONCERT

This function will be one of the features of the meeting. It had been hoped to make an announcement regarding the programme, but Mr. R. H. Findlay, Chairman of the Smoker Committee, who has so successfully organized previous functions of this character in Montreal, insists upon keeping his plans a profound secret.

### RECEPTION COMMITTEE

F. S. B. Heward, Member of Council, is undertaking the duty of Chairman of the Reception Committee. Mr. Heward says that he and his associates on this Committee will do everything in their power to insure that every visitor to the Semicentennial receives a warm and cordial welcome.

### VISITS

Plans are well under way for members to visit such points of interest in and around Montreal as the Harbour of Montreal; Beauharnois Power Development; Dominion Engineering Works; Montreal Water Board; Dominion Bridge Company; Canadian Car and Foundry Company; Canadian Steel Foundries; C.N.R. Shops.

## Committee on Consolidation

**Report for February 1937**

Since the inception of the Provincial Professional Associations, there has been a growing demand for closer co-operation between the engineering organizations in Canada through a truly representative national body.

The reports of Special Committees, Plenary Meetings of Council and Annual General Meetings during the past ten years, provide conclusive evidence of the strong desire that the gap between the legal and technical functions of the profession be effectively bridged and provision made for the elimination of those divergencies in ideal and action which, due to a multiplicity of unrelated engineering organizations, undermine the unity and impede the progress of the profession.

The Committee on Consolidation, including representatives appointed by the Dominion Council of the Professional Associations, has completed two years of concentrated study of this problem, during which they have carefully considered all suggestions and recommendations for its solution. The conclusions of the Committee are expressed in the proposed revisions to the By-laws of The Institute now submitted for your approval in the form of a ballot.

These By-law revisions were approved by the Seventh Plenary Meeting of Council on October 16th, 1936, but with an amendment to Sub-section 7 (*b*). A majority of the Branches of The Institute, six of the Professional Associations and the Corporation are not in favour of this amendment and, in addition, it has been pronounced impracticable and would involve serious contention with the Associations. *In order that Consolidation might be a possibility, the Committee had to decline to accept the Council's amendment to Sub-section 7 (b).*

On January 28th, 1937, the Fifty-first Annual General Meeting approved these By-law revisions without amendment and with specific acceptance of the Committee's Sub-section 7 (*b*).

Discussions at this and other meetings indicate a strong and widely-held opinion that unless The Institute is prepared to take its proper place as the national organization of the profession as provided for under these By-laws, it will forfeit its position as the major engineering organization in Canada. Outside the appointment of a Councillor from each Component Association, there is no change in the administration or function of The Institute or the election of its officers. As to the handing over of The Institute and its autonomy to any outside organization, The Institute will continue to be administered and its policies determined only by members of The Institute.

It has been claimed that the Committee's Sub-Section 7 (*b*) will exclude a certain type of engineer from becoming a member of The Institute. This is not a fact, as any engineer in any province, who so desires and is properly qualified, may become a member of The Institute on exactly the same conditions as any other engineer in that province.

The proposals of the Committee represent an earnest endeavour to harmonize the expressed requirements of the profession with established conditions in a workable and generally acceptable plan which will make possible that close and effective co-operation between all groups and grades of engineers in Canada essential to a strong, united, national, professional body.

In order that the proposals of the Committee on Consolidation may become effective, it is essential that the membership of The Institute endorse *all* the Committee's revisions, *including its Sub-section 7 (b)*.

Gordon McL. Pitts,
*Chairman.*

## ELECTIONS AND TRANSFERS

At the meeting of Council held on February 19th, 1937, the following elections and transfers were effected:

*Members*

CARR, Noel Osmond, Colonel, R.C.A., (Grad. R.M.C.), Director of Mechanization and Artillery, Department of National Defence, Ottawa, Ont.

HURTER, Alfred Theodore, (Ecole Polytechnique Federale, Zurich), Abitibi Power and Paper Co. Ltd., Iroquois Falls, Ont.

*Associate Member*

SCHERMERHORN, Henry Lewis, (Queen's Univ ), district engineer of municipal roads, Dept. of Highways of Ontario, Napanee, Ont

*Juniors*

HEROUX Georges, B.A.Sc., C.E. (Ecole Polytech., Montreal), asst. city engr., Three Rivers, Que.

HOGG, Allan Douglas, B.Sc., (Univ. of Sask.), student, factory course, Massey Harris Co. Ltd., Toronto, Ont.

SHAW, Frederick W. B., B.Eng., (McGill Univ.), junior engr. Steel Company of Canada, St. Lambert, Que.

*Transferred from the class of Junior to that of Associate Member*

COBBOLD, Robert James, A.C.G.I., (City and Guilds Engrg. Coll.), asst. engr., outside erecting dept., English Electric Company, Rugby, England.

GRIME, Leonard, B.A.Sc., (Univ. of Toronto), struct'l. dftsman., Hamilton Bridge Company, Hamilton, Ont.

*Transferred from the class of Student to that of Associate Member*

CHOROLSKY, Eugene, B.A.Sc., (Univ. of Toronto), designing and estimating, Canadian Bridge Co. Ltd., Walkerville, Ont.

STRATTON, Frederick Stephen, B.Sc., (Univ. of Man.), asst. in charge of supervn. of various factories, Chloride Electrical Storage Co. Ltd., London, England.

TARR, Francis Gilbert Aubrey, B.A.Sc., (Univ. of B.C.), M.S. (Cornell Univ.), Ph.D. (Univ. of Toronto), switchboard engrg. dept., Can. Gen. Elec. Co. Ltd., Peterborough, Ont.

*Transferred from the class of Student to that of Junior*

DUFF, Duncan Clemens Verr, B.Sc., (N.S. Tech. Coll.), supervisory operator on processing and refining equipment, Tropical Oil Company, Barranca-Bermergha, Colombia, South America.

KOEHLER, Julius Wilbur, B.Sc., (McGill Univ.), lighting service engr., Can. Gen. Elec. Co. Ltd., Montreal, Que.

*Students Admitted*

ARNASON, Einar, (Univ. of Man.), 628 Victor St., Winnipeg, Man.

DRYDEN, Laurence Elliott, B.Sc., (Univ. of N.B.), 298 Aberdeen St., Fredericton, N.B.

JACOBS, David Sinclair, (McGill Univ.), 146 Wolseley Ave., Montreal West, Que.

LACOMBE, Jean L., (McGill Univ.), 301 St. Louis Square, Montreal, Que.

MacLEOD, Gordon Ross, (McGill Univ.), 4585 Harvard Ave., Montreal, Que.

MACNUTT, Ernest Gerrard, (McGill Univ.), 4308 Montrose Ave., Westmount, Que.

MILLER, John Jackson, (Univ. of Man.), 632 Jessie Ave., Winnipeg, Man.

SADLER, Wilfred Robertson, (Univ. of Man.), 211 Belvidere St., Winnipeg, Man.

SMITH, Allan Garfield, (McGill Univ.), 7446 Wiseman Ave., Montreal, Que.

SWINGLER, Russell Henry, (Queen's Univ.), 250 Alfred St., Kingston, Ont.

WILSON, Bertram H. J., (Univ. of Man.), 149 Monck Ave., Norwood, Man.

# George Joseph Desbarats, C.M.G., Hon.M.E.I.C.

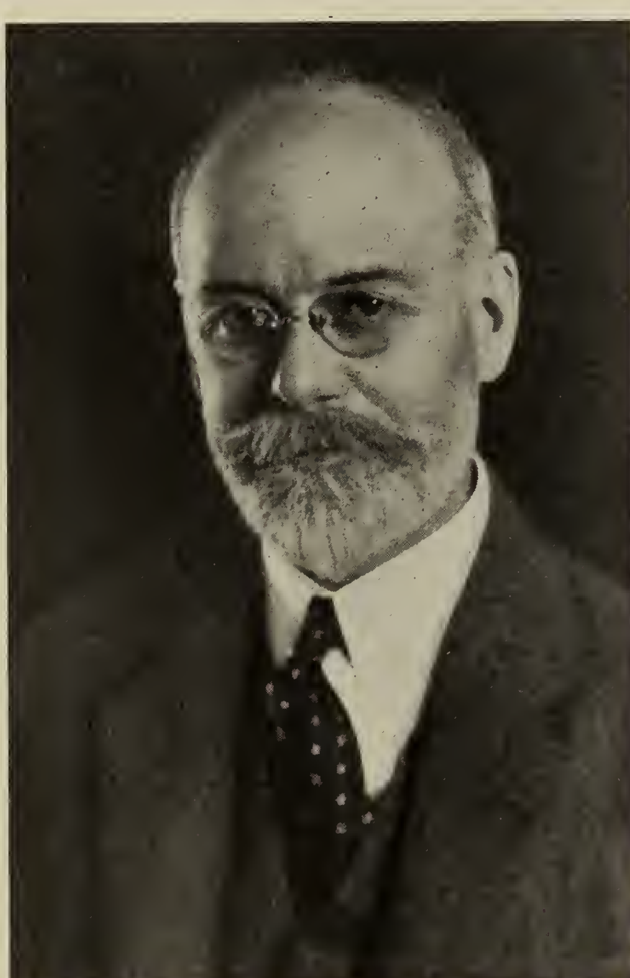
Ten years ago the presidential chair of The Engineering Institute of Canada was occupied by a distinguished French Canadian, Dr. A. R. Decary, a member of the Dominion Civil Service. Since then two other eminent Civil Servants have passed the chair, Dr. Charles Camsell and Mr. A. J. Grant. For the year 1937 the choice for President has fallen upon one of Dr. Decary's compatriots, whose professional life has also been spent in the Government Service.

The early engineering work of Mr. Desbarats was along lines typical of the varied activities of several departments of the Federal Government. During his later career as an administrative officer he was the executive head of one of that government's most important departments. Mr. Desbarats has achieved well-merited success as a public servant in both these fields of work.

Born in 1861 in the province of Quebec, he was educated at the college at Terrebonne, and at the Ecole Polytechnique, Montreal, where he graduated with honours at the age of eighteen. Entering the service of the Dominion Government in 1879 as assistant engineer in the Department of Railways and Canals, he began his professional work at the time when some of the most important sections of our canal system were being built. He was engaged on the design and construction of the Carillon Canal, the locks at Ste. Anne de Bellevue, and later the Canadian locks at Sault Ste. Marie, the Welland Canal and the Soulanges Canal.

In 1892 he was appointed Inspector of Railways in British Columbia for the Dominion Government, serving there for four years.

He then severed his connection with the Government service, and for the next three years was engineer for Messrs. Larkin and Sangster, the contractors for the construction of the Galops Canal.



G. J. Desbarats, C.M.G., Hon.M.E.I.C.

Later, returning to the Government Service, he was in charge of a hydrographic survey on the St. Lawrence from 1899 to 1901.

He was then appointed director of the Government shipyard at Sorel, and was responsible for the reconstruction of that establishment and its subsequent operation under the then Department of Marine and Fisheries. Promotion soon followed. In 1909 Mr. Desbarats was appointed Deputy Minister of the Department, and in the following year, on its organization, became Deputy Minister of the Department of Naval Service, a position to which heavy responsibility attached during the war. His service in this capacity were recognized in 1915, when he was made a Companion of the Order of St. Michael and St. George.

During the war his Department undertook many duties in addition to its regular war-time activities in connection with the naval defence of Halifax, Sydney and the St. Lawrence. Among these may be mentioned the construction of a fleet of one hundred and fifty mine-sweepers for the Admiralty, and a smaller fleet of torpedo motor launches, as well as the supply of their crews. In fact, during the war, the Department acted generally as agent in Canada for the British Admiralty.

The Department also organized the Royal Canadian Naval Air [Service (the precursor of the present R.C.A.F.), constructed air stations at Halifax and Sydney for the defence of those ports, and enrolled a large number of pilots for the Royal Naval Air Service.

In 1923 the Government decided to establish a Department of National Defence, and to merge in it the existing Departments of Militia and of Naval Service, together with the Air Board. The three military services were thus brought under one administration, and Mr. Desbarats became the Deputy Minister of the new Department. He held that appointment with distinction until his retirement from the Service nine years' later.

During this period his ability as an administrator found full scope, not only in the strenuous days of 1914 to 1919, but also in the succeeding years during which there were so many changes in organization and in the development of new technical branches of Government work. In Canada, for example, this period saw the rise of modern aerial navigation, with its profound influence on transportation problems of all kinds. Mr. Desbarats early perceived the commanding position which air transportation must take in Canada, a country of such vast distances and with such immense and sparsely populated areas. Accordingly under him there grew up an active civil aviation branch in addition to the Royal Canadian Air Force.

During the next few years the Department surveyed the Trans-Canada Airway, contructing and operating the links between Montreal and Windsor, and from Winnipeg to Calgary and Edmonton. These routes were provided with beacons, directional radio-beams, teletype communication and meteorological service. They functioned until the depression came, when they had to be discontinued; they are now being revived under the new Department of Transport.

At this time, under the Department of National Defence, there were also constructed and operated a chain of radio-stations extending from Edmonton north to Dawson and Herschel Island, providing communication with these far northern regions and thus facilitating the mining developments which have since taken place.

Apart from these activities, the department of which Mr. Desbarats was the chief executive had to administer the armed forces of Canada, and at the same time to keep abreast of many new technical problems arising in connection with all arms of the service, a notable example being the mechanization of army equipment both for fighting and transport, under Canadian conditions.

During his period of public service Mr. Desbarats held a number of important appointments additional to his departmental work, having served as plenipotentiary delegate from Canada to the Wireless Conference in London in 1912, and as Canadian Government representative to the Seamen's Conference, League of Nations, in Genoa, in 1920.

During Mr. Desbarats' long connection with The Institute, which he joined as a Member in 1897, he has taken an active part in its affairs. He served on Council in 1900, 1907, 1933 and 1934; was a vice-president in 1909, and was elected an Honorary Member in 1936. He has now been distinguished by election as President. He has always been active in the affairs of the Ottawa Branch, of which he was chairman in 1931. His wise counsel and knowledge of public affairs has been of the greatest benefit in connection with any difficult questions which have arisen, concerning either The Institute or the branch to which he belongs.

# The Fifty-First Annual General Meeting

**Convened at Headquarters, Montreal, on January 21st, 1937, and adjourned to the Windsor Hotel, Montreal, on January 29th, 1937.**

The Fifty-First Annual General Meeting of The Engineering Institute of Canada commenced at Headquarters on Thursday, January twenty-first, nineteen hundred and thirty-seven, at eight o'clock p.m., with Past-President F. P. Shearwood, M.E.I.C., in the chair.

The Secretary having read the notice convening the meeting, the minutes of the Fiftieth Annual General Meeting were submitted, and on the motion of C. K. McLeod, A.M.E.I.C., seconded by J. L. Busfield, M.E.I.C., were taken as read and *confirmed.*

### Appointment of Scrutineers

On the motion of R. H. Findlay, M.E.I.C., seconded by I. S. Patterson, Jr.E.I.C., Messrs. B. R. Perry, M.E.I.C., and J. A. Lalonde, A.M.E.I.C., were appointed scrutineers to canvass the Officers' Ballot and report the result.

There being no other formal business, it was *resolved,* on the motion of J. L. Shearer, A.M.E.I.C., seconded by P. E. Jarman, M.E.I.C., that the meeting do adjourn to reconvene at the Windsor Hotel, Montreal, at ten o'clock a.m., on the twenty-ninth day of January, nineteen hundred and thirty-seven.

## Adjourned General Meeting at the Windsor Hotel, Montreal

The adjourned meeting convened at ten fifteen a.m., on Friday, January 29th, 1937, with President Cleveland in the chair.

The Secretary announced the membership of the Nominating Committee to nominate the officers of The Institute for 1938 as follows:

### Nominating Committee—1937

*Chairman:* W. H. Munro, M.E.I.C.

| *Branch* | *Representative* |
|---|---|
| Halifax Branch | H. Fellows, A.M.E.I.C. |
| Cape Breton Branch | F. W. Gray, M.E.I.C. |
| Saint John Branch | F. P. Vaughan, M.E.I.C. |
| Moncton Branch | H. B. Titus, A.M.E.I.C. |
| Saguenay Branch | N. F. McCaghey, A.M.E.I.C. |
| Quebec Branch | L. P. Méthé, A.M.E.I.C. |
| St. Maurice Valley Branch | J. F. Wickenden, A.M.E.I.C. |
| Montreal Branch | P. E. Bourbonnais, A.M.E.I.C. |
| Ottawa Branch | C. M. Pitts, A.M.E.I.C. |
| Peterborough Branch | W. M. Cruthers, A.M.E.I.C. |
| Kingston Branch | A. Jackson, A.M.E.I.C. |
| Toronto Branch | J. J. Traill, M.E.I.C. |
| Hamilton Branch | H. B. Stuart, M.E.I.C. |
| London Branch | D. S. Scrymgeour, A.M.E.I.C. |
| Niagara Peninsula Branch | C. G. Moon, A.M.E.I.C. |
| Border Cities Branch | J. Clark Keith, A.M.E.I.C. |
| Sault Ste. Marie Branch | A. E. Pickering, M.E.I.C. |
| Lakehead Branch | H. G. O'Leary, A.M.E.I.C. |
| Winnipeg Branch | F. V. Seibert, M.E.I.C. |
| Saskatchewan Branch | A. P. Linton, M.E.I.C. |
| Lethbridge Branch | P. M. Sauder, M.E.I.C. |
| Edmonton Branch | H. R. Webb, A.M.E.I.C. |
| Calgary Branch | J. R. Wood, M.E.I.C. |
| Vancouver Branch | A. S. Gentles, M.E.I.C. |
| Victoria Branch | J. N. Anderson, A.M.E.I.C. |

### Awards of Medals and Prizes

The Secretary then announced the award of the various prizes and medals of The Institute, and stated that it is intended to make the actual presentations at the dinner which will be held in Montreal in June at the time of the Semicentennial Celebrations.

*The Sir John Kennedy Medal* to J. G. Sullivan, M.E.I.C., Winnipeg, Man., Past-President of The Institute.

*The Duggan Medal and Prize* to P. L. Pratley, M.E.I.C., Montreal, for his paper "The Superstructure of the Reconstructed Second Narrows Bridge, Vancouver."

*The Gzowski Medal* to David Boyd, A.M.E.I.C., Lachine, Que., for his paper "Modern Arc Welding."

*The Plummer Medal* to C. R. Whittemore, A.M.E.I.C., Montreal, for his paper "The Metallurgy of Metallic Arc Welding of Fine Steel."

*The Leonard Medal* to L. S. Weldon, M.C.I.M.M., Kenya, E. Africa, for his paper "Mining Methods and Practice at Lake Shore Mine."

### Students' and Juniors' Prizes

*John Galbraith Prize* (Province of Ontario) to E. C. Hay, Jr.E.I.C., Toronto Ont., for his paper "Selection of Factors of Photo Electric Cells."

*Phelps Johnson Prize* (Quebec—English) to Eric G. Adams, Jr.E.I.C., New York (formerly Montreal), for his paper "Trends in Population and Trade Affecting Transportation."

*Ernest Marceau Prize* (Quebec—French) to Louis Trudel, S.E.I.C., Montreal, for his paper "Etude Comparative sur Modèles Reduits."

### Report of Council and Treasurer's Report

The Secretary read the report of Council for 1936, and J. B. Challies, M.E.I.C., presented the Treasurer's report, after which, on the motion of Mr. Challies, seconded by Past-President Shearwood, the report of Council and the Treasurer's report were *adopted.*

### Report of Finance Committee

P. L. Pratley, M.E.I.C., chairman of the Finance Committee, presented that committee's report, together with the financial statement, which, on the motion of Mr. Pratley, seconded by W. McG. Gardner, A.M.E.I.C., was *adopted.*

### Reports of Committees

The Secretary then indicated some points of interest in the reports of the various committees, and they were presented for approval, after which, on the motion of

P. L. Pratley, M.E.I.C., seconded by G. A. Gaherty, M.E.I.C., it was *resolved* to adopt the following reports: Library and House Committee, Papers Committee, Board of Examiners and Education, Honour Roll and War Trophies Committee, Committee on Relations with National Societies, Committee on Western Water Problems, Committee on Deterioration of Concrete Structures, and the Employment Service Bureau.

J. L. Busfield, M.E.I.C., then presented the report of the Semicentennial Committee, which, on the motion of G. Stead, M.E.I.C., seconded by E. Viens, M.E.I.C., was *adopted.*

Report of the Committee on Consolidation

Following the presentation of the above committee reports, that of the Committee on Consolidation was submitted to the meeting. W. McG. Gardner, A.M.E.I.C (Montreal), *moved* the following resolution, which was *seconded* by E. Viens, M.E.I.C. (Ottawa):

> That the chairman of the Committee on Consolidation read the report of his committee or such portions thereof as he may consider necessary to provide a proper background for the discussion of the report. This presentation of the report to be followed by a period not exceeding thirty minutes, during which questions relative to the report may be asked of the chairman of the committee. Following this question period the recommendations of the committee attached to the report to be considered separately and consecutively, and so passed upon by the Annual Meeting; all resolutions from branches and Associations relative to Subsection 7 (*b*) to be presented to the meeting before the discussion of the committee's recommendation Number 2.

Mr. Gardner explained that the intent of his motion was that the chairman of the Committee on Consolidation might have an opportunity to speak to the report and answer any questions, following which the recommendations of the committee would be considered item by item, and dealt with in an orderly fashion.

Mr. Pratley did not like the resolution, as he feared that if adopted it might tend to limit the discussion only to the recommendations. He thought that it should be possible at this meeting to discuss the consolidation question from all points of view.

Mr. Challies remarked that the purpose of this meeting was to give every latitude in discussion. He hoped that Mr. Pitts would have a free hand in presenting his report.

G. Mc.L Pitts, M.E.I.C., stated that he had himself drawn up the resolution with no thought of limiting the discussion on any point that might be raised. His reason in suggesting a thirty-minute question period was because at the last annual meeting at Hamilton a similar motion had worked very satisfactorily.

Mr. Pratley said that everyone wished to give Mr. Pitts all the liberty he required, but the resolution appeared to limit the discussion to the questions which might be asked or to the recommendations, and would thus prevent a general discussion, which, in his opinion, was very desirable.

Mr. Pitts said that the only reason for the motion was to indicate a regular system of procedure and he was sorry that Mr. Pratley felt that there was anything which was calculated to limit discussion.

The President remarked that if the resolution passed, as chairman of the meeting he would have to be bound by the wording of the resolution.

Mr. Pitts then expressed his willingness to strike out the words "not exceeding thirty minutes" and *moved* an amendment to that effect.

Mr. Pitts' amendment, having been *seconded* by W. Chase Thomson, M.E.I.C. (Montreal), was put to the meeting and *carried,* after which the original motion, omitting the deleted phrase "not exceeding thirty minutes," was put and *carried.*

Mr. Pitts, in presenting the report of his committee, remarked that this meeting, with the ballot, would close the first phase of the effort to get closer co-operation between the professional bodies in Canada. He could assure the meeting that his committee had worked at this problem most diligently for the past two years, particularly in the last year. He wished to express his personal thanks to his committee members for their efforts. The committee's work had cost a good deal more money than he had ever thought likely, the explanation being the amount of printing and the distribution of the printed matter necessary to keep all interested parties informed.

Having read the principal paragraphs of his report, Mr. Pitts remarked, with reference to the questionnaire which his committee had issued in June 1935, that some Institute members had questioned the reliability of the figures which he had based on the replies to that questionnaire. He could only say that the questionnaire had been sent out in such a way as to give every member of The Institute an opportunity of expressing a personal opinion, either individually or through his branch executive committee. Thus, the committee had done their best to ascertain the opinion of The Institute membership, particularly as to whether the corporate membership of the Provincial Professional Associations and the national organization should be identical.

Mr. Pitts drew attention to the appendices to the report, giving respectively the committee's proposals for amendment of The Institute by-laws; an index suggesting a desirable way of renumbering the by-laws; a suggested form of agreement between a professional association and The Institute; a suggested form of application for admission to The Institute by a member of a Professional Association, and finally a suggested form of ballot. With regard to the latter, Mr. Pitts explained that the form suggested called for a single vote on all the by-laws submitted by the Committee on Consolidation exclusive of Subsection 7 (*b*), this subsection being voted on separately. He sincerely hoped that at the present meeting no amendment would be added to those proposals on which the committee and the Council had come to an agreement.

In closing, Mr. Pitts urged that every member of The Institute should register his vote, because the future of The Institute was now in the hands of its members, and depended on the result of the ballot.

The President thanked Mr. Pitts for his presentation, and stated that there was now an opportunity for questions.

J. A. McCrory, M.E.I.C. (Montreal), desired to ask two questions. First, assuming the adoption of the proposals so that The Institute could only accept into corporate membership members of the Professional Associations, had the Committee on Consolidation any idea of the number of associations which would reciprocate by accepting into their membership members of The Institute, particularly in view of the fact that there would possibly be an increase in the fees of the associations. Secondly, he would like to ask whether the Committee on Consolidation had made any estimate of the revenue which The Institute would receive under the new set-up.

In reply, Mr. Pitts stated that with regard to the admission of Institute members to the associations, certain of the associations were taking steps to make this possible, but in Mr. Pitts' opinion, if a man had the qualifications for admission to The Institute the examining boards of the associations could be trusted to reciprocate. He had, however, no authority to speak on this point, and it could only be answered by the Councils of the Associations themselves. With regard to finance, a statement as to the probable financial situation after consolidation had been presented at the Plenary Meeting of Council. It had been drawn up by The Institute's Finance Committee and indicated that, with the Committee on Consolidation's original proposals, a deficit of around $2,000 might be expected, this being probably because the proposals included that of abolishing the class of Associate Member and reducing the Members' fee to that now paid by Associate Members. This point had, however, been taken care of in revising the committee's proposals by proposing that the Associate Members' fees would be increased $1 above their present level.

Mr. McCrory understood from Mr. Pitts that there had been no commitment by the Dominion Council or the Provincial Associations as to their becoming component associations. Mr. Pitts replied that several provincial associations were taking definite steps to come in under the provisions of the new by-laws providing that they are approved by The Institute membership. Mr. Pitts had letters and resolutions indicating the definite position of some of the associations, but Mr. Kirby, the President of the Dominion Council, would no doubt be able to speak on this point.

Vice-President E. V. Caton, M.E.I.C., stated that as regards the Manitoba Professional Association they were definitely committed, in the event of consolidation going through, to accept automatically, without entrance fee, all corporate members of The Institute then in good standing in the province of Manitoba. He thought that this indicated, as far as Manitoba was concerned, a very co-operative spirit.

C. C. Kirby, M.E.I.C. (Saint John), said that if this were the proper time to answer questions as to the attitude of the various Provincial Associations he would like to make a statement on the matter.

A telegram had been received from the registrar of the Nova Scotia Association stating that the annual meeting of that Association supported the proposals of the Committee on Consolidation.

In New Brunswick the Association, at its recent annual meeting, had resolved that the Association would become a component association of The Engineering Institute at as early a date as possible, without loss of the identity of the Association or its functions under the Provincial Act.

The registrar of the Association of Saskatchewan had written that the proposals of the Committee on Consolidation had met with entire approval, and were acceptable to that Association.

Mr. Caton had reported as regards Manitoba.

In respect to the Province of Quebec, Mr. Kirby had not received any official communication, but there were representatives of the Corporation present who would no doubt make a statement.

As regards Alberta, Mr. Kirby was not able to give any definite information.

In British Columbia the annual meeting of the Association of Professional Engineers in December had passed a resolution sympathetic to the proposals for consolidation.

One definite statement had been received declining to enter consolidation, namely, that from the Association of Professional Engineers of the Province of Ontario, contained in a letter dated January 23rd, 1937, which Mr. Kirby read.

In response to a question, Mr. Kirby stated that the approximate numbers of members of the various Provincial Associations were, in 1936:—Nova Scotia—200; New Brunswick—125; Ontario—1,146; Saskatchewan—88; Alberta—256; British Columbia—815; Quebec—927, a total of 3,557, exclusive of Manitoba.

S. R. Banks, A.M.E.I.C. (Montreal), desired to draw attention to the concessions which would be made by The Institute to the Professional Associations if the present proposals carried. He felt that the abolition of the class of Associate Member and the transfer of present Associate Members to the class of Member would not raise the status of The Institute's corporate members in any way. The present Associate Members were nearly twice as numerous as the Members, so that the resulting grade as to general professional experience would on the average be nearer the present Associate Members' status than that of the present Members. All Associate Members' fees would be slightly higher, a hardship on the younger men, whereas the senior members, better able to pay higher annual fees, would have a reduction. Mr. Banks further pointed out that while there was a provision in the proposals for the automatic expulsion from The Institute of a member expelled from a component association, there was no corresponding provision calling for the expulsion from a component association if expelled from The Institute. It would therefore appear that a person expelled from The Institute still remaining a member of a Provincial Association could at once apply again and rejoin The Institute.

H. S. Johnston, M.E.I.C. (Halifax), asked for an interpretation with regard to Subsection 7 (*b*). He thought that the wording did not indicate clearly whether corporate membership in a Professional Association would be the sole requirement for admission to The Institute, or whether it would be only one of a number of requirements. He thought the wording of this subsection should be clarified on this point.

W. Chase Thomson, M.E.I.C. (Montreal), asked whether he was correct in assuming that corporate membership in an Association would be full and sufficient evidence of eligibility for admission to The Institute, and Mr. Pitts replied that any full member of an Association accredited by his Association would be admitted to The Institute as a Member.

F. S. B. Heward, A.M.E.I.C. (Montreal), understood that Mr. Pitts had stated that The Institute supported Subsection 7 (*b*) as proposed by the Committee on Consolidation, but Mr. Heward desired to point out that at the Plenary Meeting of Council held in October The Institute Council was not in agreement with the proposed Subsection 7 (*b*) as put forward by the Committee on Consolidation, the reasons being, first, that the committee's version involved the surrendering of the autonomy of The Institute, and, secondly, that it would exclude from The Institute a great many fully qualified engineers not now members of a Professional Association, nor required by law to be members. In Mr. Heward's opinion Subsection 7 (*b*) was the crux of the situation. There were some who believed that the whole consolidation movement would be wrecked unless the committee's proposal for Subsection 7 (*b*) was adopted, because in this event some of the Professional Associations would no longer be interested in the proposals. Mr. Heward desired to point out that on the other hand there were many members of The Institute who felt that unless the Council's proposal was agreed upon the consolidation movement would not be advanced.

In reply Mr. Pitts stated that The Institute Council itself, up to the time of the Plenary Meeting in October, had accepted the principle of Subsection 7 (*b*) as proposed by the committee. He did not know the Council's reasons for the reversal of opinion which took place at that time, or whether the general membership would support that reversal of opinion. Mr. Pitts suggested that questions of this kind regarding Subsection 7 (*b*) would be more properly discussed when recommendation number two of his committee was under consideration.

Mr. H. S. Johnston remarked that Nova Scotia believed that autonomy should rest in the provinces, and that considerations with regard to membership and qualifications for membership should be decided by the provinces.

Clarence M. Pitts, A.M.E.I.C. (Ottawa), thought that members of The Institute should have additional information as regards the position of the Ontario Association, of which he was a member. He had received a copy of a Christmas message from the President of the Association in which it was stated that the Ontario Association desires to co-operate with other Associations of Professional Engineers, but could not consolidate the members of the various branches in a general Canadian Engineering Institute. "Institute consolidation," said the President, "is for The Institute representing the various branches." From this Mr. Pitts gathered that the Ontario Association is definitely opposed to any scheme such as that now before The Institute. He judged that the Ontario Association did not desire to have one national body representing engineering in Canada, but would like to have separate associations directing civil engineering, mechanical engineering, mining engineering, and so on. If this view was prevalent in the Ontario Association the co-operation of that body would not be possible.

H. R. Sills, A.M.E.I.C. (Peterborough), desired to draw attention to the provisions of Sections 9 and 10 in the proposals, regarding the qualifications for Juniors and Students, in whose cases age limits of 33 and 27 respectively had been specified. This arrangement had existed in The Institute by-laws for some time, and he believed that the younger members had taken undue advantage of it. In his opinion, Students and Juniors, as soon as they attain the age limit should become liable for the fee of the next grade of membership, whether they apply for it or not. This would be helpful in the way of finance, and would bring these men out of the lethargy to which some of them were liable. Mr. Sills hoped that this point would receive consideration.

Mr. Pitts remarked that Mr. Sills had raised a point not definitely related to consolidation, therefore one which his committee had not taken up. It would, of course, be impossible to put such a suggestion in the ballot at this time.

Mr. Pratley inquired whether in closing the question period it would be permissible to discuss such general features as were now being brought up. Would this be possible when dealing with the recommendations seriatim?

The President explained that the intention was that the meeting have every opportunity to consider every phase of the subject, but he hoped that the direct questions could be dealt with first, so that the recommendations could be proceeded with.

Frederick Bridges, M.E.I.C. (Sorel), drew attention to the proposed provision by which members of Professional Associations might become Associates of The Engineering Institute. They would then presumably be able to attend meetings and have all the privileges except that of voting. He did not think that this offered any inducement to a member of a Professional Association to join The Institute as a corporate member.

Mr. Pitts explained that the arrangement of which Mr. Bridges had spoken was intended to be applicable in the case of those of the associations amongst whose members there were some who did not desire to become active members of The Institute. Its intention was to bring every engineer in some way in contact with The Institute in order to encourage his relationship with it. In the case of an Association becoming a Component Association under Subsection 7 (*a*)1 the question would not arise, but it might arise in a case where an Association was not yet ready to bring in all its members at once and therefore could not take advantage of the fee advantage which total membership would bring. He felt that if the present proposals went through it would be realized that The Institute had taken a broad liberal view, and from the information which he had received he believed that that feeling would be reciprocated in the Associations.

At this point the President extended a welcome to Mr. C. E. Davies, Secretary of the American Society of Mechanical Engineers, who was present; his visit had been a source of great pleasure to the meeting.

Mr. Davies, in a few words of greeting, expressed his pleasure at being able to attend, and complimented The Institute members on the way in which their very complicated problem was being approached. He might say, however, that the complexity of the situation in Canada, although sufficiently great, was small in comparison with the difficulties of the similar problem in the United States.

The meeting adjourned at twelve forty-five p.m. to reconvene at 2.15 p.m.

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The meeting reconvened at 2.15 p.m. with the President in the chair.

The President having asked whether any member desired to ask any further direct questions, the meeting proceeded to the consideration of the seven recommendations with which the report of the Committee on Consolidation concludes.

*Recommendation No. 1.*

> That the Council of The Institute and the Committee on Consolidation being in agreement on all the proposed revisions to the By-laws of The Institute as appearing in Appendix "A" of this report, with the exception of Sub-Section 7 (*b*), these revisions be accepted by the Annual Meeting and be sent forward to ballot by the general membership without further amendment.

Recommendation No. 1 having been read, E. P. Muntz, M.E.I.C. (Hamilton), *moved* the acceptance of the recommendation and this motion was *seconded* by Geoffrey Stead, M.E.I.C. (Saint John).

Mr. McCrory did not agree with this proposal and was of the opinion that the whole of Section 7 should come under discussion; he then *moved* that the recommendation be amended by changing the words "Subsection 7 (*b*)" to "Section 7."

Mr. McCrory's amendment having been *seconded* by G. P. Hawley, M.E.I.C. (Montreal), Mr. Pitts desired to point out that if the amendment were carried the consideration of the whole question would be thrown into confusion, the reason being that Subsection 7 (*b*) was the only paragraph on which Council and his Committee were not in agreement. Recommendation No. 2 had to do with Subsection 7 (*b*) only, but any other portion of Section 7 could be properly considered under the heading of Recommendation No. 1.

Mr. McCrory was still unable to agree with Mr. Pitts. As he understood it, if the meeting voted for Recommendation No. 1 that would practically shut out further discussion of everything except Subsection 7 (*b*).

Mr. Pitts replied that discussion of everything except Subsection 7 (*b*) was now in order, and this was confirmed by the President.

Mr. McCrory was of opinion that quite a number of important proposals were included in Section 7, and he felt that there was some inconsistency in its various provisions. For instance, Subsection 7 (*a*) provided that the Council shall admit any corporate member of an Association upon application duly made and upon presentation of the credentials requested under the by-laws. On the other hand, Subsection 7 (*d*) said that every candidate who has not graduated from a school of engineering would be required to pass an examination. There seemed to him to be some inconsistency here, and he thought these clauses should be clarified.

Mr. McCrory having *withdrawn* his amendment, with the agreement of his seconder, Mr. Pitts explained that the difficulty really arose because the two concluding paragraphs of Section 7, namely, Subsections 7 (*c*) and 7 (*d*), should really be taken together. Both paragraphs should, in fact, be combined as Subsection 7 (*c*). Subsection 7 (*a*) provides for the admission of corporate members of an Association; Subsection 7 (*a*)1 for the admission of all members of an Association by registration of its total membership; Subsections 7 (*c*) (including 7 (*d*)) for the admission of those members who do not reside in a province where there is a Component Association. These three subsections, therefore, provide for the admission of Members to The Institute in three different ways.

G. J. Desbarats, HON.M.E.I.C. (Ottawa), asked whether the meeting could have put before it a definition of its powers under the by-laws.

The Secretary having read the second half of Section 75 of the By-laws, pointed out that the question had been considered at the Plenary Meeting of Council, at which time it was decided that the intent of the clause was that the decision as to what amendments, if any, are to go to ballot in addition to the printed proposals, should be the decision of a majority of the members present at the Annual General Meeting. Under the by-laws, the proposals of the Committee on Consolidation and the proposals put forward by Council, having been duly published and put before the membership, must go to ballot, but they might be accompanied by such amendments to the proposals as this Annual General Meeting might decide to put forward in addition.

R. H. Findlay, M.E.I.C. (Montreal), inquired whether difficulty would not arise in case all of the by-laws were approved on ballot with the exception of Subsection 7 (*b*).

Mr. Pitts pointed out that if the Council had been agreeable to all the amendments of the Committee on Consolidation there would only have been one vote to place upon the ballot paper. Possibly the meeting would rather discuss Subsection 7 (*b*) first, and then pass on the balance of the by-laws.

Mr. Kirby thought that Mr. Findlay was under a misapprehension in suggesting that if all the other recommendations were passed and Subsection 7 (*b*) did not, serious difficulty would arise. That was not the case. As far as consolidation was concerned, all of the machinery was provided in other sections, and would work independently of Subsection 7 (*b*). Members would note that Subsection 7 (*b*) is merely a prohibition, preventing The Institute from admitting members under certain circumstances. He would also point out that Council had not recommended that Subsection 7 (*b*) be thrown out entirely, but had wished to see the prohibition qualified. Mr. Kirby understood that the Quebec Corporation might be prevented from becoming a Component Association if Subsection 7 (*b*) was not passed. That, however, was merely their choice, and the total omission of Subsection 7 (*b*) would not place any obstacle in their way.

Mr. Heward remarked that the whole question of the revision of the by-laws had been based on the hope that there would be consolidation. It would be very unfortunate if The Institute should be left in the position of changing its by-laws and then finding that the Professional Associations did not want the proposed arrangement. Why change the by-laws if consolidation was not going to carry?

Mr. Pitts pointed out that if none of the Associations agreed to co-operate under the scheme the present method of functioning of The Institute would not change at all. The only effect of the proposed changes in the by-laws in that case would be the abolition of the class of Associate Member, a principle which had been accepted for many years, and with this exception there would be no change in The Institute's organization.

Mr. Pitts desired to state that the committee and the Council had now studied this matter over a period of two years. These bodies had had before them all the correspondence and expressions of opinions from individuals, from branches, and from the Associations. The result had been the scheme which was now before the meeting. Possibly members in studying the proposals might see some points which they thought might present difficulty. He could assure members, however, that his committee and Council were satisfied that the scheme was workable, and he believed the meeting would be quite safe in taking Recommendation No. 1 as Council and the Committee had approved it.

Mr. Heward remarked that a number of members did not believe that the present scheme is exactly the form of consolidation desired by the majority. If the proposals fail to carry on ballot then that should terminate the matter, and the Council of The Institute should be left free to make progress with regard to consolidation along other lines.

Mr. Pitts desired to ask Mr. Heward, in view of the remarks just made, whether he had in mind a scheme for professional consolidation which he honestly thought was better than the one now put forward by the committee, and which has been under discussion for two years. If so, why had Mr. Heward not communicated his scheme to Council and to the committee?

Mr. Heward said that in his opinion the present movement was not one for consolidation but one for absorption of The Institute by the Professional Associations. If there were a genuine desire on the part of the Associations to enter into closer relations with The Institute that might be accomplished without having to surrender the autonomy of The Institute or shutting the door in the face of a great many engineers who are fully qualified for Institute membership, but who are not required to be members of Professional Associations. Mr. Heward believed that a much simpler revision of the by-laws of The Institute could be arranged, providing for closer working arrangements with the Professional Associations without running the danger of surrendering to them the autonomy of The Institute.

Mr. Pitts considered that in that case Mr. Heward, as a councillor of The Institute, had failed in his duty in not putting his scheme before The Institute before this.

Mr. Heward replied that he had addressed a communication to the Committee on Consolidation in which he strongly urged a compromise with regard to Subsection 7 (*b*).

Mr. Pitts remarked that the communication to which Mr. Heward had referred was a letter to the committee sent after the Plenary Meeting of Council, and Mr. Heward's recommendation had been, not that the scheme of consolidation should be changed, but that the committee should adopt the Council's version of Subsection 7 (*b*).

Mr. Findlay said that if he understood Mr. Heward correctly, the thought was that a certain section of The Institute was going to be seriously penalized by the proposed by-laws. Mr. Findlay would call Mr. Pitts' attention to the report of his committee which had been published in The Journal for February 1936 and which had been presented at the 1936 Annual Meeting. In that report it was stated that there are three classifications of engineers in each province, namely, (A) those who are members of The Engineering Institute and also of a Professional Association; (B) those who are members of The Institute but who do not belong to a Professional Association, and (C) those who are members of Professional Associations and not of The Institute. In the proposals now before the meeting, as published in the December 1936 Journal, Mr. Findlay had found that classes (A) and (C) had been provided for, but no provision had been made for class (B). In fact, in Mr. Pitts' reports it was stated that this class would tend to disappear. The proposed amendments to the by-laws would now make that tendency into a definite fact.

Mr. Findlay desired to point out the large proportion of The Institute membership who are in class (B). In the province of Quebec this class amounted to more than forty-five per cent of the membership of The Institute in that province. It included large numbers of engineers employed by manufacturing and industrial companies; it was the class which produced the largest number of papers read before The Institute, and was the most valuable and active in the dissemination of professional knowledge. It was this class which, under the amended by-laws, would disappear.

Mr. Findlay agreed with Mr. Heward that the committee had planned only for an Institute composed of Association members. He felt that the committee had been so busy discussing details that they had not dealt with the principles on which these details should have been based. Why had not the chairman of the committee adhered to his original suggestion as a method of approach to the problem, namely, that a group of Institute representatives in each province should meet with a group of Association representatives, and, after coming to an agreement, should report to the Committee on Consolidation? This would have been a common-sense method. The committee had had a heavy task, but Mr. Findlay believed that the personnel of the committee had made it impossible for them to handle the matter in the manner just referred to. There was not on the Committee on Consolidation a real representative of the large class of engineers to whom Mr. Findlay had referred, namely, those employed by large manufacturing and industrial companies. He thought that most members of The Institute would agree that the committee had been more association-minded than Institute-minded. Mr. Findlay urged the acceptance of Council's revision of Subsection 7 (*b*), in which case, while there was nothing to prevent the Associations coming in, this large group of valuable members of The Institute would be preserved. If, after a few years, conditions changed, there would be nothing to prevent the revision of Subsection 7 (*b*) at that time if thought wise to do so.

The President pointed out that while Mr. Findlay's review was interesting, and possibly mistakes had been made, it was his duty to point out that the meeting should confine itself directly to the questions that arise out of the recommendation which was under consideration.

It seemed to Mr. Pratley that the consideration of Recommendation No. 1, which was now proceeding, would give the only opportunity for general discussion. The succeeding recommendations were all definitely directed to some particular point. He suggested that discussion on general features must be held now or not at all. Questions should now be opened up which would lead to considerations regarding the proposal of amendments, if any. The object of this meeting was not to accept everything given to it, but to discuss with a view of proposing such amendments as might be acceptable.

The President remarked that the meeting was open at this point to any discussion that would be crystallized in the form of an amendment.

W. Chase Thomson, M.E.I.C., pointed out that members might possibly be inclined to agree with Recommendation No. 1 if one of the two forms in Recommendation No. 2 were agreed to, whereas they might not agree at all to Recommendation No. 1 if the alternate form of Recommendation No. 2 were adopted. In Mr. Thomson's opinion the whole of the proposals including Subsection 7 (*b*) should be discussed in detail as Mr. Pratley had said.

Mr. Pitts wished to reply to Mr. Findlay's suggestions, which were, first, that members of The Institute, not members of the Professional Associations, were not affected by the proposals, which was not the case, and secondly, that the committee had been association-minded. The committee had been engineering-minded, that is, socially-minded as far as the engineering profession was concerned. He thought Mr. Findlay's presentation had been a little unfair to the committee whose purpose had been to do the best job it could for all engineers in Canada. In regard to its guiding principles, his committee had supposed, up to the 16th of October, that The Institute was in favour of the principle of accepting only Association members into the organization after consolidation had carried, and it was only at the eleventh hour that a change of opinion by the Council had brought in the difference expressed in the two proposals for Subsection 7 (*b*).

Mr. Pratley did not think Mr. Pitts' reply had disposed of what Mr. Findlay had stated. The fact that those members who belong only to The Institute (class B) had been generously treated by the committee and had been left in The Institute, did not remove the necessity for considering the future. A large percentage of the younger Institute members belonged to this class, which there was no reason to suppose was about to disappear. Mr. Pitts was willing at the moment to let those members stay in The Institute who did not belong to the Associations. During the next ten years many people would come along who are not in the Associations, but who should belong to The Institute. Under the proposals they would be kept out.

A. R. Ketterson, A.M.E.I.C. (Montreal), suggested that time would be saved if the discussion were confined at present to Subsection 7 (*b*). If so, he would propose to take with it the consideration of a portion of Section 11 providing for the disappearance of the class of Affiliates. In Mr. Ketterson's opinion this change was undesirable.

Mr. Pitts stated that his committee had proposed the dropping of the class of Affiliates of The Institute because every useful purpose served by that class would continue to be served by the class of Branch Affiliates, which had been retained. Any engineer who could enter The Institute now would be able to enter if the proposals were passed.

Mr. Heward did not agree with Mr. Pitts. The matter was a question of principle. Men who are not required by law to be members of a Provincial Professional Association should not be obliged, in future, if they desire entrance to The Institute, to register with a provincial body.

Mr. H. S. Johnston remarked that up to the Plenary Meeting in October, Nova Scotia had not been satisfied with the progress made by the Committee on Consolidation. After the Plenary Meeting they felt more hopeful, as the co-ordination proposed by the Committee on Consolidation appeared to be likely to develop into real consolidation, which was what the Nova Scotia members desired. Subsection 7 (*a*)1, providing for a Provincial Association to come in as a body into The Institute, had given Nova Scotia what it wanted to a large degree, and if put into effect there would mean that all the engineers in that province would voluntarily enter the consolidated profession.

With regard to the class to which Mr. Findlay had referred, Mr. Johnston thought that they should join the Professional Associations for the sake of the profession at large. Why should they insist on standing outside in a class by themselves? In Nova Scotia, however, it was believed that the present proposals showed real progress as a result of two years of earnest work. The committee had made an earnest effort. Its report had been practically accepted by the Plenary Meeting of Council, a large assembly at which all the provinces were represented. He hoped that the proposals would be accepted by the membership at large, and that the progress of the last two years would not be put aside so that a new beginning would have to be made.

Mr. Findlay desired to point out to Mr. Johnston, on behalf of himself and forty-five per cent of The Institute members in the province of Quebec who are not members of the Quebec Corporation, that they did not join that body, as its work meant nothing to them, and for that reason they did not see why the Corporation should be the only door by which they could get into The Engineering Institute.

J. L. Rannie, M.E.I.C. (Ottawa), remarked that as a Dominion Civil Servant, he was another Institute member who did not have to join the Professional Association. In this he was one of a large percentage of the Ottawa Branch of The Institute, who had nevertheless realized that to get into The Institute, after the passage of the proposals, they would have to join the Provincial Association. They had accepted this condition at the Annual Meeting of the Branch without a single dissenting voice. The Ottawa members had enough interest in consolidation to say that if in order to get somewhere it was necessary to give something up they were prepared to do so.

Mr. Muntz supported Mr. Rannie's view, and stated that he wished to convey to the meeting the opinion of the Hamilton Branch, which was to exactly the same effect. That Branch was made up almost entirely of members who are employed engineers and are not interested in the Professional Association from the legal standpoint. Nevertheless they are backing the Committee on Consolidation and are prepared to join the Association if that is necessary for consolidation.

Mr. Busfield recalled that at the Plenary Meeting of Council he had requested a clear explanation of the necessity for these drastic changes in the by-laws, and the reply he had received was that he should read the reports of the Committee on Consolidation. This he had done, and he had found that one of the objects of the Committee on Consolidation was to take care of the group of engineers who do not belong to the Professional Associations, a group to which Mr. Findlay had already referred. All he found in the by-laws, however, was that this group would be compelled to belong to the Professional Associations. He found also in the proposals that without any guarantee of consolidation whatsoever, the privilege of membership in The Institute was to be given away to any Association desiring to take advantage of it. He also noted that one recommendation of the Committee's report of last year was that the Provincial Professional Associations should be approached to give reciprocal privileges to The Engineering Institute as regards recognition of membership. In the proposals now before the meeting he found nothing of this kind, although a report from Manitoba had stated that if the proposals go into effect Manitoba will recognize Institute membership. On the other hand, it had been stated that other Associations had definitely gone on record that they did not propose to give any recognition to Institute membership. Mr. Busfield felt, therefore, that many of the recommendations of last year had not been implemented in the proposals now submitted.

In these proposals Mr. Busfield had failed to find anything which could really be called consolidation. The Institute itself, under these proposals, would operate under entirely different conditions in the eight provinces. That was not consolidation, but in his opinion, as far as The Institute was concerned, was a breaking down rather than a building up.

He found nothing in the picture indicating any consolidation of the Professional Associations themselves. There was nothing in the proposals which would have any effect of this kind, except the provision for a Standing Committee, which neither the Associations nor The Institute needed. He had heard that some associations are ready to become component. This was understandable since they had everything to gain and nothing to lose. Mr. Busfield had, therefore, come to the conclusion that the effect of the proposed changes would be to hand over the control of the national body and The Institute's privileges to the Professional Associations. Our grades of membership were to be changed so as to have one grade of corporate member to fit the ideas of the Professional Associations. The Institute's qualifications would be entirely changed so as to admit members of the Professional Associations. Then a group of Associates would be set up for the benefit of those members of the Association who do not want to belong to The Institute, taking these men in without any fee whatever.

None of these proposals were really based on a determination of what is really needed in the profession, but had been made to fit the conditions found to exist in the different provinces. Mr. Busfield questioned the desirability of eliminating the class of Affiliates simply because they did not fit in with the provincial arrangements. Other national engineering societies had had such a grade for many years. He had noted further that the method of application for transfer was to be greatly simplified and made automatic in the case of Association members, but The Institute would retain its present standards of admission in provinces where there were no component associations. All the changes proposed in methods of election and transfer were entirely to the advantage of the Associations.

It seemed to him inevitable that the Provincial Associations would in a short time have the absolute control of The Institute. This arrangement of a national body directed by eight Provincial Associations would possibly be workable, although he could see some very definite disadvantages. In the first place the membership of the national engineering body, heretofore built up of men selected for technical and professional engineering qualifications, would be on a different basis from the selection of Association members. He believed that there were cases where persons had been admitted to the Provincial Associations for reasons quite apart from their technical qualifications.

The ultimate control of The Institute by the Provincial Associations had been definitely visualized by the President of the Dominion Council of Professional Engineers in reviewing the proposals now before the meeting. In a memorandum on the Manitoba proposals, which Mr. Busfield understood had been distributed in British Columbia and elsewhere, Mr. Kirby had stated that the Association members, as nominators and electors of The Institute Council, would in time control the personnel of that Council, so that ultimately the by-laws of The Institute could be made to comply fully with the requirements of the Associations. Mr. Busfield would suggest that the real question to be discussed to-day by the meeting would be, is it advisable for the Provincial Associations to control The Institute?

Mr. Pitts desired to point out that The Institute would always be run by the members of The Institute.

Mr. H. S. Johnston desired to add that Mr. Busfield should have included Nova Scotia with Manitoba as an Association which would grant reciprocal privileges.

Mr. Kirby remarked that Mr. Busfield had criticized him for pointing out to the professional engineers in Canada that they are not being absorbed by The Institute but are being brought into The Institute. The proposal which Mr. Busfield disliked came from the Plenary Meeting of Council itself, when The Institute Council adopted the Manitoba proposals as to group membership, and said to the Associations "we are glad to have you come in as a body." Mr. Kirby would urge that if there were going to be a real national engineering body in this country, all engineers must be in it or it would not be a real national society. When everybody had joined, the majority would rule;

The Institute had already committed itself to the principle that engineers should be registered. In Mr. Kirby's opinion it was right and proper that the provincial engineers of Canada should have the majority vote in the affairs of The Institute. Why should The Institute's policies be dominated by a group residing close to headquarters who are not sympathetic to the principle of registration for engineers? Such domination was not in accordance with the view of The Institute itself, which had gone on record as approving the desirability of registration for engineers in Canada.

Brian R. Perry, M.E.I.C. (Montreal), pointed out that although Mr. Findlay had suggested that forty-five per cent of The Institute members in the province of Quebec were not interested in registration, nevertheless in replying to the questionnaire sent out by the committee asking for an expression of opinion, approximately eighty per cent of the Montreal members had turned in ballots in favour of the proposals now before the meeting. Mr. Perry did not agree with Mr. Kirby that a group of members of the Council representing the Montreal Branch were opposed to consolidation. In Mr. Perry's opinion rejection of the present proposals by the membership could only result in increased activity on the part of the Professional Associations along lines which are at present the functions of The Engineering Institute. There would not be room in any locality for two organizations whose objects would clash in this manner.

Mr. Perry then drew attention to the increased activity noticeable in Montreal and in Toronto on the part of American and other engineering associations of a specialized character, and pointed out that young engineers joining them did not see much point in paying a double fee, so that these bodies were gaining membership to a large extent at the cost of the membership in The Engineering Institute. In many cases the members of these associations were not qualified engineers, but they called themselves engineering societies. This would lead the Professional Associations to take an interest in their activities, in doing which the Associations would tend to overlap the functions of The Engineering Institute.

F. P. Shearwood, M.E.I.C. (Montreal), desired to point out that the question at issue was apparently whether at this time licensing should be made compulsory for every future member of The Engineering Institute. Actually, the possibility of the complete application of licensing had not been demonstrated, especially in the provinces of Ontario and Quebec. The voluminous reports published from time to time by the Committee on Consolidation had dealt largely with the background of the subject and had not answered questions such as the following: (1) What must be classed as and be licensed for professional practice in engineering, especially as it is carried on in industry? (2) Will the present proposals improve our personal incomes or our reputations as members of the profession? (3) Will they define more honestly and more convincingly the responsibility of engineers to the public? (4) Will they bring into The Institute those highly experienced employees of industries who contribute so much to engineering progress, but who do not belong to The Institute, and give their allegiance to foreign societies? (5) Will the proposals of the committee encourage the interchange of experience which is at the root of engineering development? These questions should be investigated and reported on.

The Committee on Consolidation had claimed justification for many of their proposals because of large majority votes at Annual Meetings and favourable answers to questionnaires, but in Mr. Shearwood's opinion these votes had nearly always been given in general approval of the movement for co-operation and should not be taken as an endorsement of the particular proposals contained in the committee's reports. Mr. Shearwood himself, in voting for the committee's report of last year did not thereby necessarily endorse all its proposals. Undue significance should not be given to majority votes at Annual Meetings. He had repeatedly pointed out to the committee that their members were not sufficiently conversant with the requirements of engineers employed by industries, no member of the committee having had responsible charge of large industrial departments. Thus he feared that the committee had not appreciated the difference between the requirements desirable for an engineering licence and those required for service in the industries. Further, the committee had not realized the unprofessional character of the work of the sales-engineer.

Mr. Shearwood's experience in industrial work had made him realize the need for an efficient licensing system giving protection to those aspiring to consultant service and serving as a guarantee to the public. While the committee was insisting on the inclusion of Subsection 7 (*b*) restricting membership in The Institute to members of the Provincial Associations, they had failed to state what engineering work can be and is restricted to licensed engineers. This being so, why were some forty-five per cent of The Institute members in the province of Quebec not registered? These men, many of whom are prominent members, are not forced to pay $7 per annum to the Corporation for the right to earn a living by engineering, and it did not seem fair to compel all future members to pay this amount for a licence which most of them do not require. The raising of the standard of engineers' professional qualifications had been given as the reason for Subsection 7 (*b*), particularly in the Province of Quebec, and yet the standard for admission to the Quebec Corporation was actually lower than that required for corporate membership in The Engineering Institute.

Mr. Shearwood felt that the present proposals of the Committee, except Subsection 7 (*b*), could be accepted by both The Institute and the Associations to their mutual benefit, but that subsection should be approved in the form recommended by Council, so that the complete control of all future membership in The Institute would not be given over to the provincial bodies, at least not until the scope and benefits of licensing had been clearly defined.

Mr. Pitts noted Mr. Shearwood's remarks, in which he had criticized the Committee on Consolidation for not elaborating the ideals which he had laid out. It would have been impossible to bring forward proposals along Mr. Shearwood's lines, as these would require a complete change in the existing Acts of the various provinces, a practical impossibility. Mr. Pitts' committee had made every effort to find out the opinions of people in all parts of the country. In regard to Subsection 7 (*b*), Mr. Pitts would point out that the version proposed by his committee had been supported by the branches in Victoria, Vancouver, Edmonton, Calgary, Saskatchewan, Winnipeg, Lakehead, Niagara Peninsula, Hamilton and Ottawa. The Montreal Branch Executive could not make up its mind. The branches at Quebec, Saint John and Halifax had approved the committee's version of Subsection 7 (*b*). Their version had also been approved by the following Associations: British Columbia; Alberta; Saskatchewan; Manitoba; Quebec; New Brunswick and Nova Scotia. Ontario had not done so. These expressions were what the committee had to go by in making their decisions, and they should be contrasted with the action of the Plenary Meeting of Council, which had approved a different version by a vote of 13 to 8. Mr. Pitts did not see how the expressions of branch opinion to which he had referred could be overlooked.

Mr. Crealock desired to make a personal explanation. Mr. Kirby had already read to the meeting a letter from the President of the Ontario Association of Professional Engineers, which stated the view of the Council of that Association as not being in favour of the scheme of consolidation put forward by The Institute's Committee on Consolidation. He had been on that committee as one of the two representatives appointed by the Dominion Council of Professional Engineers. Mr. Crealock was also a member of the Council of the Professional Association in Ontario, and in view of the attitude taken by that Council he now found it necessary to submit his resignation as a member of the Committee on Consolidation. That he had done, and he desired the meeting to be made aware of the fact.

Speaking next as a member of The Institute Council representing the Toronto Branch of The Institute, Mr. Crealock reported that the executive committee of that branch, on October 7th, 1936, had passed a resolution supporting Council's version of Subsection 7 (*b*). On January 21st, 1937, following the announcement of the attitude of the Ontario Association, that executive committee had passed the following resolution "that the previous motion of the executive committee passed on October 7th, 1936, recommending an amendment to Subsection 7 (*b*) of the report of the Committee on Consolidation, be rescinded." At the same meeting it was also resolved "that the branch councillors be instructed to support at the Annual Meeting Subsection 7 (*b*) as contained in the report of the Committee on Consolidation."

Mr. E. V. Caton desired to point out that the Winnipeg Branch appreciated the generous gesture made by The Institute in the proposals now before the meeting. With these amended by-laws, the Manitoba members believed they could get what they regarded as essential, namely, one body representing the engineering profession in Manitoba. Under the new by-laws it would be possible to register practically the whole body of engineers in Manitoba, who would pay one fee, which he believed would possibly be less than the one fee now paid, and certainly less than the two fees now paid by some. The Institute would thus be strengthened in Manitoba. Mr. Caton believed that if each province were given an opportunity to consolidate under the auspices of The Institute there would soon be a national engineering body with The Institute as a head. In the west it was felt that if The Institute is to become the national body it should have all members of the profession within it.

Mr. W. McG. Gardner felt that if Recommendation No. 1 of the committee were adopted, and the proposals carried on ballot, there would be a national body, but there would not be The Institute. He believed the impossible was being attempted, namely, a unification scheme which not everybody would join.

G. H. Wood, A.M.E.I.C. (Niagara Falls), pointed out that two views had been expressed, one, that The Institute would be dominated by the Professional Associations, and another, that the Professional Associations would be dominated by The Institute. He did not think that either would be the case. Some members seemed to have the idea that there was some stigma attached to voluntary registration, and that a man who does so is not quite as good as the man who refuses to register unless compelled to do so. Mr. Wood could not understand such a view.

Geoffrey Stead, M.E.I.C. (Saint John), believed that the feeling was strong for consolidation in New Brunswick, and that if consolidation did not go through he feared The Institute would suffer rather than the Professional Association. In New Brunswick they believed the present proposals to be a good working set of by-laws, and in fact the New Brunswick Association had resolved to become a component association as soon as possible.

Mr. Shearwood inquired whether a provincial act could cover all engineering work. Mr. Wheatley had admitted that such acts could not do so.

In reply Mr. Stead read from the New Brunswick Act the description of a professional engineer.

Mr. Shearwood observed that the Committee on Consolidation, and also the Quebec Branch, had referred to a report made by a committee of which he had been chairman. It would have been better if they had read the last paragraph of the report to which he referred, in which he had suggested that a committee be appointed to investigate and report on (*a*) the conditions existing in the engineering shop and field departments of large engineering works and contracting and manufacturing corporations, (*b*) the class of work and type of training necessary for the various engineering employees of these corporations, and (*c*) the policy of The Institute in regard thereto.

Mr. Kirby suggested that the time to appoint such a committee would be after consolidation when there would be one big body of engineers representing everybody.

Mr. Pratley remarked that Mr. Kirby's reference to one big body would serve him as a text. In regard to the committee's proposals, numerically small bodies would have a very easy task as, for example, in Saskatchewan with 88 members; New Brunswick with 121, and in Manitoba, but in the larger Associations such as Ontario, Quebec and British Columbia the problem was not so simple. Mr. Pratley had before him a letter from the Council of the Association in British Columbia, of which he was a member, containing the statement that the Committee on Consolidation is moving too quickly in this matter. Mr. Pratley agreed with this, particularly because there was no assurance from the three large provinces, without whose co-operation consolidation would be a farce, that they are prepared to co-operate. It was definitely known that Ontario would not do so. The Quebec Corporation would only do so with a very one-sided interpretation of qualifications. Mr. Pratley did not see why the Corporations and The Institute should not mutually agree to let each other function and to help each other without trying to join together an unequal bunch of quite different bodies.

In British Columbia Mr. Pratley understood that on January 19th a meeting had been called by the Council of the Professional Association to discuss or protest against the proposals now before The Institute. At that meeting Mr. Vilstrup, the President of the Association, had said, "Here, in British Columbia, the view has been consistently held for many years that the logical procedure in the matter of consolidation would be for the Provincial Associations to establish a permanent Dominion body with which then consolidation with The Engineering Institute of Canada and perhaps other bodies could be subsequently arranged." . . . "While those of us not members of The Engineering Institute of Canada may feel we are not interested or concerned with by-law revisions, we cannot, nevertheless, escape important consequences if they pass and result in consolidation." . . . "Those of us not members of The Engineering Institute of Canada cannot vote for or against the proposed by-laws, although the result of the by-laws may greatly affect the destiny of our Association, but we are free to discuss them."

These extracts from Mr. Vilstrup's speech would show that in British Columbia they are not prepared to accept the proposals of the Committee on Consolidation. During the meeting of the B.C. Association the opinion was expressed that those proposals were dangerous, and instead of uniting engineers across Canada the result would be quite the opposite. Mr. Pratley agreed with this opinion. At the same meeting the Vice-President of the British Columbia Association, not a member of The Engineering Institute, had advocated a federation of the Provincial

Associations joined together and equal, and the claim was made that the proposals emanating from The Engineering Institute of Canada did not contemplate such an arrangement, "some members of The Engineering Institute of Canada having appointed themselves to the task of making The Engineering Institute of Canada the Dominion body." These views, expressed by people prominent in the British Columbia Association, were considered so important that the Association had published them. It did not seem likely that the British Columbia Association would be willing to enter into consolidation on the present proposals. Thus, if those proposals carried, the three major provinces would still operate as they are now quite independently of The Institute. This would result in difficulty. Why would it not be better to take the thought expressed by the British Columbia Council that we are going too fast?

Colonel H. F. G. Letson, M.E.I.C., the Past-President of the British Columbia Association, had suggested in his presidential address that, following the procedure initiated in the United States, a National Engineering Council should be formed in Canada, representing such bodies as The Engineering Institute of Canada, the Canadian Institute of Mining and Metallurgy, the Provincial Associations, and the members of the various foreign engineering societies having branches in Canada. Mr. Pratley did not think such a proposal had yet been explored; such exploration should be a task for The Institute.

Speaking as one of the Montreal councillors, Mr. Pratley said that the representatives of the Montreal Branch on Council had agreed to the committee's proposals involving the surrender of The Institute's autonomy, but had felt they were wrong in doing so. They had not opposed the approval of those proposals by Council, because they were not opposed to the principle of co-operation or federation; further, in doing so they had not misrepresented the branch on the question of Subsection 7 (*b*) as Mr. Perry had suggested. Actually, the Montreal Branch had never discussed Subsection 7 (*b*), though the branch had recorded its approval of consolidation as a principle.

Mr. Pratley would like to make one last plea—that members should think very seriously before giving consent to the present proposals, which were dangerous, because if they carried, membership of The Institute would become merely a matter of registration. There would then be little value in putting M.E.I.C. after one's name, since, if the proposals carried, members would have to accept as their equals, as corporate members of The Institute, graduates of our various schools of engineering without any engineering experience whatever. For fifty years membership in The Engineering Institute of Canada had been a certificate of standing. If the by-laws were amended as now proposed this would no longer be the case.

Mr. Pitts remarked that Mr. Pratley was evidently against the form of consolidation now proposed, which, for the time being at least, was equivalent to opposing consolidation. With regard to Mr. Pratley's quotations from speakers in British Columbia, Mr. Pitts pointed out that these opinions were personal and did not necessarily represent the opinion of the total membership of the British Columbia Association, in regard to which there was on record a resolution passed by the British Columbia Council indicating a point of view very sympathetic to the present proposals. There was undoubtedly a group in British Columbia definitely in opposition to The Institute, but Mr. Pitts was satisfied that these people did not represent the opinion of the majority of the members of the British Columbia Association.

Mr. Pitts did not think that Mr. Pratley was justified in saying that Quebec would not come in. There was no evidence of such a course in any communication he had had, and the Quebec Corporation was undoubtedly ready to support the movement. In regard to the Ontario Association their situation should be regarded sympathetically. They had not an effective Act, and he hoped that The Institute, as a national body, would get behind the Ontario Association and support them in getting a satisfactory enactment, so that every engineer in Ontario would be glad to enter the organization.

Mr. Pitts could not report enthusiastically that British Columbia was coming into consolidation, at all events for the time being.

The question having been called, the Secretary read the resolution with regard to Recommendation No. 1, as proposed by Mr. Muntz, seconded by Mr. Stead, that the meeting accept Recommendation No. 1 as follows:—

> "That the Council of The Institute and the Committee on Consolidation being in agreement on all the proposed revisions to the By-laws of The Institute as appearing in Appendix "A" of this report, with the exception of Subsection 7 (*b*), these revisions be accepted by the Annual Meeting and be sent forward to ballot by the general membership without further amendment."

The resolution having been put to the meeting was *carried* with applause.

*Recommendation No. 2.*

> That in view of the attitude of the majority of the Professional Associations on Subsection 7 (*b*) and in the interests of achieving Consolidation, every effort be made to accept the Committee's proposal on this Subsection without modification or amendment for submission by ballot to the general membership.

E. P. Muntz, M.E.I.C., then *moved* that Recommendation No. 2 be approved, his motion being *seconded* by G. Lorne Wiggs, A.M.E.I.C. (Montreal).

The President pointed out that under the By-laws, Subsection 7 (*b*), as proposed by the Committee, and the alternative version of Subsection 7 (*b*), as proposed by the Council, must both go to the general membership for ballot.

Mr. Findlay desired to *move* that in view of the large number of Institute members who are not members of the Professional Associations, this meeting go on record as approving the Council's revision of Subsection 7 (*b*). Mr. Findlay's motion having been *seconded* by J. L. Busfield, M.E.I.C., the President pointed out that the motion being equivalent to a direct negative of the main motion must be disallowed. The same result would be obtained if the recommendation of the committee were disapproved.

Mr. Gordon Pitts pointed out that Recommendation No. 2 was equivalent to a request to this meeting to express its opinion as to which version of Subsection 7 (*b*) was preferable.

Mr. Pratley was unable to accept this view, and Mr. Pitts pointed out that while both proposals must go to ballot, his committee hoped that this meeting would approve Subsection 7 (*b*) and direct that it go forward without any further amendment.

Mr. Clarence Pitts did not agree with Mr. Pratley as to the meaning of the committee's recommendation. That committee was asking for the meeting's approval of their version of that subsection. Council's proposals seemed to Mr. Pitts to be almost inexplicable. By the use of the words "required by law" they would place the matter in the hands of the Courts so that the engineering profession would have to go to the legal profession in order to find out who an engineer is. Council thought this was simplifying the problem, but it actually made more complication. The resolution asked the Annual Meeting to endorse the position of the Committee on Consolidation, Mr. Pratley hoped that it was quite clear that Council's amendment to Subsection 7 (*b*) would go to ballot. Mr. Clarence Pitts had referred to the difficulty of deciding who is "required by law" to be a member. In Mr. Pratley's view this was a simple matter, since in a province having an effective Act, the mere fact that an engineer is not a member of the Professional Association implies that the law does not require him to be so, the Professional Association not having taken action in his case.

The resolution for the approval of Recommendation No. 2, proposed by Mr. Muntz and seconded by Mr. Wiggs, was then put to the meeting and *carried* by a vote of 39 to 17.

*Recommendation No. 3.*

That the Annual Meeting approve the form of the "Memorandum of Agreement" between The Institute and a Component Association, as submitted in Appendix "C" of this report, subject to such modification within the terms of the By-laws as may be agreeable to the Council of The Institute and the Associations and Corporation.

The Secretary having read Recommendation No. 3 as above, Mr. Muntz *moved* its approval, and his motion was *seconded* by Mr. G. H. Wood. There being no discussion, the motion was put to the meeting and *carried.*

At this point Mr. Pratley, *seconded* by T. C. Thompson, A.M.E.I.C. (Montreal), *moved* that the meeting adjourn, but on being put the motion was *lost.*

*Recommendation No. 4.*

That the Annual Meeting approve Form "C" as proposed by the Committee in Appendix "D" of this report, being the form of Application for Admission to The Institute by a member of a Provincial Professional Association or Corporation.

*Recommendation No. 5.*

That the ballot on the By-law proposals be drawn in the general form as appearing in Appendix "E" of this report and that the Committee on Consolidation be authorized to take part in the drafting of the form of the ballot.

*Recommendation No. 6.*

That subject and subsequent to the approval of the By-law proposals by a ballot of the membership, the By-laws be re-arranged and re-numbered before being printed and issued to the membership in accordance with the Index appearing as Appendix "B" of this report.

*Recommendation No. 7.*

That the Committee on Consolidation be continued as presently constituted to function in connection with the preparation of the ballot, and otherwise for the purposes of Consolidation, until after the results of the ballot have been announced, and that thereafter a special committee be appointed by Council to actively promote Consolidation.

The approval of Recommendations Nos. 4, 5, 6 and 7 was then *moved* by Mr. C. C. Kirby, *seconded* by Mr. G. H. Wood, on which Mr. Findlay *moved* as an amendment that Recommendation No. 5 be changed to say that the ballot on the by-law proposals be prepared by Council with the co-operation of the Committee on Consolidation. The amendment having been *seconded* by Mr. T. C. Thompson, was put to the meeting and *lost.*

Mr. Challies desired to ask Mr. Pitts with regard to Recommendation No. 6, the renumbering and rewording of the by-laws, whether Council would be precluded from making minor changes in wording. Mr. Challies would like to see this point covered in the recommendation, and, with the agreement of Mr. Gordon Pitts, *moved* as an amendment the addition to Recommendation No. 6 of the words "or such modification thereto as Council may determine." The amendment having been *seconded* by Mr. Gordon Pitts was put and *carried.*

The main motion for the adoption of Recommendations 4, 5, 6 as amended, and 7 was then put and *carried.*

Mr. Gordon Pitts desired to *move* that the meeting adopt the report of the Committee on Consolidation with the revisions as they have been approved and with the amendments suggested under the various clauses. The resolution having been *seconded* by Mr. Challies was put to the meeting and *carried.*

### Amendments to the By-laws Proposed by the Council

The meeting next considered the amendments to The Institute by-laws proposed by the Council, of which copies had been distributed to the members present.

Mr. H. S. Johnston *moved* that the amendments proposed by Council be approved for ballot, the motion being *seconded* by Professor McKiel.

Mr. Clarence Pitts pointed out a difficulty with regard to Subsection 7 (*b*), the meeting having already approved of the committee's version of that Subsection. He accordingly *moved* an amendment that the proposals of Council be approved with the exception of that referring to Subsection 7 (*b*). The amendment was *seconded* by J. A. Lalonde, A.M.E.I.C. (Montreal), and on being put to the meeting was *carried.*

### Branch Reports

The meeting next considered the branch reports. The President suggested that unless representatives from any of the branches desired to draw special attention to some particular point these reports might be taken as read and accepted. Mr. McCrory, having *moved* that the branch reports be accepted, his motion was *seconded* by E. Viens, M.E.I.C., put to the meeting and *carried.*

Mr. Gordon Pitts drew attention to the many letters and resolutions which had been received from The Institute branches with regard to the committee's proposals, more particularly as to Subsection 7 (*b*). He asked that this correspondence should be printed in the record of the Annual Meeting for the general information of the membership of The Institute.

The Secretary having pointed out that if all the letters were included the material would be somewhat voluminous, Mr. Pitts agreed that a list of the resolutions and letters, with a brief statement of their contents would be sufficient. Mr. Pitts then *moved* that a summary of the communications from the branches with reference to consolidation should be printed with the record of the Annual Meeting. His motion having been *seconded* by Hector Cimon, M.E.I.C. (Quebec), was put to the meeting and *carried.*

This summary list of communications follows:—

| From: | Received: 1936 | Remarks |
|---|---|---|
| Saskatchewan Branch | Nov. 26th | Favours Committee's Subsection 7 (*b*). Urges that ballot be submitted to membership in such a form as to permit of a single vote on major question of consolidation. |
| Quebec Branch | Dec. 8th | Resolution and letter signed by 24 corporate members of Quebec Branch favouring Committee's Subsection 7 (*b*). |
| Winnipeg Branch | Dec. 18th | Endorsing Saskatchewan resolution. |
| | 1937 | |
| Calgary Branch | Jan. 2nd | Favouring Committee's Subsection 7 (*b*). |
| Lakehead Branch | Jan. 2nd | Endorsing Saskatchewan resolution. |
| Saint John Branch | Jan. 12th | Endorsing Saskatchewan resolution. |

| | | |
|---|---|---|
| Kingston Branch | Jan. 16th | Suggesting that Council's amendment to Subsection 7 (*b*) should apply to Ontario only, or that words "except in the case of the Province of Ontario" should be added to original Subsection 7 (*b*). |
| Niagara Peninsula Branch | Jan. 19th | Recommending Council to reconsider decision of Plenary Meeting re Subsection 7 (*b*). |
| Saguenay Branch | Jan. 19th | Favouring Council's amendment to Subsection 7 (*b*). |
| Ottawa Branch | Jan. 19th | Favouring Committee's Subsection 7 (*b*) and urging that ballot be submitted in such a form as to permit of a single vote on major question of consolidation. |
| Lethbridge Branch | Jan. 20th | Favouring Committee's Subsection 7 (*b*). |
| Vancouver Branch | Jan. 23rd | Favours Committee's Subsection 7 (*b*). Urges that ballot be submitted without alternative choice for Subsection 7 (*b*). |
| Winnipeg Branch | Jan. 25th | Favouring Committee's Subsection 7 (*b*). Urges that separate ballot be taken on Subsection 7 (*b*) if alternative proposals are sent out. |
| Victoria Branch | Jan. 25th | Favouring Committee's Subsection 7 (*b*). Requests that Council withdraw their proposed amendment. |
| Toronto Branch | Jan. 27th | Favours Committee's proposal for Subsection 7 (*b*). |
| Hamilton Branch | Jan. 28th | Supporting Committee's Subsection 7 (*b*). |
| Halifax Branch | Jan. 28th | Choice of two alternatives for Subsection 7 (*b*) not a serious one, particularly if Subsection 7 (*a*)1 carries. But if decision will have detrimental effect on report of Committee on Consolidation will support report of Committee on Consolidation. |

Mr. Gordon Pitts desired to draw attention to the facts that the result of the ballot would be known during the month of May; the wishes of the membership thereby expressed would affect the future policy of The Institute; and many members will be present at the Semicentennial in Montreal in June. Mr. Pitts *moved* that the Council arrange for a special general meeting of The Institute in Montreal at a convenient time during the Semicentennial Celebrations, for the reception and discussion of the results of the ballot.

The motion having been *seconded* by Robert F. Legget, A.M.E.I.C. (Kingston), Mr. Pitts explained that at that meeting there would be an opportunity for representatives of the Professional Associations to indicate their attitude towards consolidation.

Mr. Busfield, as chairman of the Semicentennial Committee, said that his committee, and the Council, felt it inadvisable to hold meetings at that time dealing with general business of The Institute, the only exception being the Plenary Meeting of Council which was to form part of the Semicentennial proceedings. It was possible, he thought, that the Dominion Council of Professional Engineers might see fit to hold a meeting at that time, but Mr. Busfield did not think that a business meeting of The Institute should then be held.

Mr. Pitts, in reply, said that the meeting would be a special general meeting which would deal with no other business than that stated in the resolution.

The resolution having been put to the meeting was *carried.*

Mr. Gordon Pitts desired to make another proposal, and *moved* that the ballot on the revisions to the by-laws be issued to the membership on or before the first day of March 1937, and be returnable to the Secretary not later than the twentieth day of April 1937, and that the Council announce the result of the ballot on or before May 1st, 1937.

The Secretary pointed out that the date on which the ballot could be sent out would depend upon the time taken by the *pro* and *con* committee in preparing their statements.

S. G. Porter, M.E.I.C. (Calgary), *moved* as an amendment that the matter be referred to the incoming Council. The amendment having been *seconded* by W. McG. Gardner, A.M.E.I.C., was put to the meeting and *carried*, the resolution therefore being *lost.*

The President reminded the meeting that under the by-laws it was his duty to nominate a committee composed of an equal number of members favouring and opposing the proposals, who would prepare a statement of reasons for and against which would accompany the letter ballot. He proposed to make those appointments at the opening of the next session of the annual meeting.

At this point, six five p.m., on the motion of Mr. Clarence Pitts, *seconded* by Professor H. W. McKiel, it was *resolved* to adjourn and reconvene at ten o'clock on Saturday morning.

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The meeting reconvened at ten fifteen a.m. on Saturday, January 30th, 1937, with President Cleveland in the chair.

The Secretary presented a telegram from The Institute membership and the Professional Association in Saskatchewan, signed by D. A. R. McCannel, M.E.I.C., the President of the Association, and Councillor Stewart Young, M.E.I.C., conveying greetings, and urging the Annual Meeting to present a clear cut proposal on consolidation to The Institute membership.

The President made the following nominations as members of a committee to be appointed under Section 75 of the By-laws to edit the reasons advanced for and against the proposals: Committee on reasons for—Gordon McL. Pitts, A.M.E.I.C., J. B. Challies, M.E.I.C., O. O. Lefebvre, M.E.I.C.; Committee on reasons against: P. L. Pratley, M.E.I.C., F. S. B. Heward, A.M.E.I.C., R. H. Findlay, M.E.I.C.

In making these appointments, the President urged the desirability of limiting the length of the presentations which must accompany the ballot and suggested a memorandum not exceeding 200 words in each case.

### Address of Retiring President

Dr. Cleveland then delivered his presidential address, the subject being "The Engineer in Business." (This is published *in extenso* on pages 98 and 99 of the issue of The Journal for February 1937.)

### Election of Officers

The Secretary presented the report of the scrutineers appointed to canvass the officers' ballot for 1937, as follows, and the President declared the various nominees duly elected to their respective offices:—

| | |
|---|---|
| President | G. J. Desbarats |
| Vice-Presidents: | |
| Zone A | H. S. Carpenter |
| Zone C | J. A. McCrory |
| Councillors: | |
| Halifax Branch | H. S. Johnston |
| Saint John Branch | E. J. Owens |
| Saguenay Branch | A. C. Johnston |
| St. Maurice Valley Branch | B. Grandmont |
| Montreal Branch | J. B. D'Aeth |
| | A. Duperron |
| Ottawa Branch | R. W. Boyle |
| Kingston Branch | J. E. Goodman |
| Toronto Branch | W. E. Bonn |
| London Branch | J. A. Vance |
| Border Cities Branch | H. J. A. Chambers |
| Lakehead Branch | R. J. Askin |
| Saskatchewan Branch | R. A. Spencer |
| Edmonton Branch | R. M. Dingwall |
| Vancouver Branch | P. H. Buchan |

The newly-elected President, Mr. G. J. Desbarats, was then escorted to the chair by Past-Presidents F. P. Shearwood and S. G. Porter, who presented him to the meeting amid hearty applause.

Dr. Cleveland briefly extended a welcome to Mr. Desbarats, and expressed the hope that he would have the highest satisfaction in the discharge of his duty.

President Desbarats, on taking the chair, expressed his thanks to the members for the honour of being elected President of The Engineering Institute of Canada, particularly as this distinction came in a year which was such an important one for The Institute, as including the Semi-centennial Celebrations. He knew that in carrying out his duties he would have the full support of members of Council and of The Institute members.

The Secretary then presented the following resolution from the Ottawa Branch regarding a change in the title of The Institute:

> "That the Ottawa Branch, Engineering Institute of Canada, in Annual Meeting assembled, request the Council of The Institute to take the necessary steps to obtain assent to change the name of The Engineering Institute of Canada to The Royal Engineering Institute of Canada and that corporate members of The Institute may thereafter be designated by the abbreviation R.E.I.C., as and when consolidation proposed is effected.
>
> "Be it further resolved that a copy of this resolution be sent to the branches of The Institute and to Council to be presented at the next Annual Meeting in Montreal."

Mr. Clarence Pitts *moved* that the Annual General Meeting adopt this resolution which had been unanimously passed by the Ottawa Branch and was intended to suggest that when The Institute became truly representative of the engineers throughout Canada it might properly aspire to the honour of the title of "Royal." He hoped that the meeting would go on record as being in favour of that step when consolidation had become effective.

Mr. Challies was not only opposed to the idea on its merits, but also felt that the method proposed to secure the change of name was incorrect. Such a change could only be made as a result of the same procedure as that required for a change in The Institute by-laws.

Mr. Clarence Pitts did not agree with Mr. Challies on this point. The resolution merely asked the Council to take the necessary steps, but did not force any issue.

Mr. Challies inquired whether Mr. Clarence Pitts would be satisfied to have the whole matter referred to the Council. Further, Mr. Challies pointed out that some twenty years ago, when the name of the Canadian Society of Civil Engineers was changed, the same proposal had been brought up and had given rise to strong opposition. The suggestion was then abandoned, one of the principal reasons being that The Institution of Civil Engineers, the senior engineering society in Great Britain, had been satisfied to proceed without this honour. In Mr. Challies' opinion The Institute was in no way comparable to any of the organizations in Canada which had sought and had been granted the privilege. Further, he believed that any change in the name of The Institute at the present time would be unwise.

Mr. Clarence Pitts observed that his motion had not been seconded. He had moved that the resolution of the Ottawa Branch be adopted by the Annual Meeting. Mr. Pitts' motion was then *seconded* by Mr. Legget.

Mr. Gordon Pitts remarked that the subject should not be a very controversial one, and was not of importance in relation to the by-laws. The change suggested, however, would designate The Institute as an important national body, and distinguish it from a number of organizations which are springing up and which are making a very free use of the term "engineering." Mr. Pitts further pointed out that quite a number of The Institute branches had sent in recommendations to the Plenary Meeting of Council, but at that meeting the Council had not had time to give the matter proper consideration. Now it should be settled by The Institute. Mr. Pitts thought it would perhaps be possible to get a larger expression of opinion than was possible at a regular annual meeting as to whether the use of the title would be of sufficient significance to go to Parliament and ask for the privilege.

Vice-President Caton agreed with Mr. Challies that the present time was not opportune to introduce any additional contentious subjects. In the Manitoba Branch it was the general opinion that at the present time it was not even opportune to discuss whether or not the change was desired.

Mr. G. H. Wood stated that at a meeting of the Niagara Peninsula Branch held last fall, a motion was passed recommending that no action be taken on the matter.

Mr. Rannie desired to propose an amendment to the resolution and *moved* that the matter be presented to the Council to be taken up as the Council might find advisable. In that way the Council could take any action they desired and sound out the members of The Institute at the proper time. The amendment was *seconded* by R. L. Dobbin, M.E.I.C. (Peterborough).

President Desbarats observed that the effect of the amendment would be to refer the resolution of the Ottawa Branch to the Council for such action as they might deem advisable and possible. It would, however, hardly be a task for the 1937 Council, as consolidation could not possibly be completed during the present year.

After further discussion Mr. Crealock suggested that the mover and seconder of the resolution might with propriety defer action for a year, and Mr. Clarence Pitts, with the consent of his seconder, having *withdrawn* his motion, Mr. Rannie, with the consent of his seconder, *withdrew* his amendment.

Mr. Clarence Pitts then *moved* that the Ottawa Branch resolution be laid on the table. The motion having been *seconded* by Mr. Legget, was put and *carried.*

The Secretary presented the following resolution from the Vancouver Branch, which had been submitted to the Council at its meeting on December 18th, 1936:—

> "That the secretary be instructed to write Headquarters asking that consideration be given by Council to an amendment to The Institute's by-laws giving full proxy powers to substitutes appointed by branches to Plenary Meetings when the duly appointed councillors are unable to attend."

The Secretary reported that while the Council had felt that this suggestion deserved serious consideration, it was impossible and inadvisable, to put forth a proposal for such an amendment to The Institute by-laws at the present time. The Council had been of the opinion, however, that it would be well to get an expression of opinion from the Annual General Meeting for the guidance of the Council as to future action.

Vice-President Caton favoured such a resolution. Having served on the Council he realized the difficulty of always getting councillors from distant branches to appear at a Plenary Meeting of Council, and thought there was a real necessity for the arrangement suggested. He then *moved* that the matter be referred to the Council to be taken up at the proper time, with a recommendation for favourable action.

In *seconding* Mr. Caton's motion, P. E. Doncaster, M.E.I.C. (Fort William), observed that such a change would be a great help to a branch such as the one he represented. In the Lakehead Branch it had often been impossible, for private reasons, for their councillor to attend Council meetings, even although matters of import to the branch were to be decided. With the suggested change it would be possible, for instance, for the Manitoba representative, on his way to attend a Council meeting, to be authorized to act for the Lakehead Branch, with instructions as to his vote on any question, and in that way the Lakehead Branch would have a voice on any resolution presented to the Council at Headquarters or elsewhere.

The sense of the meeting appeared to be favourable to Mr. Caton's suggestion, but the motion was not formally put, since at this point the proceedings were interrupted, owing to the sudden illness of the President.

When the meeting was resumed the chair was taken by Vice-President R. L. Dobbin.

Mr. E. P. Muntz then *moved* that a vote of thanks be tendered to the scrutineers for their services in preparing the report on the election of officers, and that the ballot papers be destroyed. The motion having been *seconded* by Mr. G. H. Wood, was put to the meeting and *carried.*

On the *motion* of Professor H. W. McKiel, *seconded* by R. W. Boyle, M.E.I.C., it was unanimously *resolved* that the thanks of The Institute be conveyed to the Montreal Branch in recognition of their hospitality and activity in connection with the holding of the Fifty-First Annual General Meeting.

It was then *moved* by Past-President S. G. Porter that a hearty vote of thanks be accorded to the retiring President and members of Council in appreciation of the work they have done for The Institute during the past year.

Past-President Shearwood, in *seconding* this vote of thanks, said that a special acknowledgment was due to the retiring President. Any one who had been on the Council during the past year would realize the services rendered by Dr. Cleveland; and especially the sacrifice of his time in travelling to and from the Pacific, not only to Montreal but also to the Maritime Provinces. The Institute owed him a great debt of gratitude for the trouble, time and effort he had given. The resolution was *carried* by acclamation.

Mr. Viens desired to *move* a vote of thanks to the members of the Committee on Consolidation for their effective work during the past year. The motion having been *seconded* by A. Duperron, M.E.I.C., was *carried* unanimously.

Professor McKiel did not think that the meeting should adjourn without some expression of thanks to Mr. P. L. Pratley, ending his term as senior vice-president and chairman of the Finance Committee. Mr. Pratley had given a great deal of time and thought to the finances of The Institute, and his guidance had been invaluable during a very difficult period.

Professor McKiel's motion was *seconded* by Dr. Cleveland, who drew attention to the amount of work which, in his absence, had unavoidably fallen to Mr. Pratley, in presiding at Council meetings and dealing with Institute affairs from day to day.

Mr. Rannie had known Mr. Pratley for many years and desired to express admiration for his devotion to the interests of The Institute.

Vice-President Dobbin did not think there was any need of putting Professor McKiel's resolution to the meeting, the feeling of the assembly having been indicated by such vigorous applause.

Mr. Heward, before the meeting terminated, desired to voice the deep regret of the meeting at the unfortunate indisposition of the new President, and asked that at the first opportunity the Secretary would convey to Mr. Desbarats the sympathy of the meeting, and the best wishes of everyone for his speedy recovery.

Vice-President Dobbin was sure that all present greatly regretted the distressing illness of the President. The Secretary was directed to convey these expressions to Mr. Desbarats.

The meeting terminated at eleven forty a.m.

## The San Francisco - Oakland Bay Bridge

The illustration shown above is an interesting view of the San Francisco-Oakland Bay bridge, which was opened to traffic on November 12th, 1936. The bridge was built as a result of the ever-increasing demand for transportation. A ferry system handled more than four million vehicles and fifty million passengers in 1930. Plans and specifications for the bridge proper were completed late in 1932, and bids were invited early in 1933. In the same year the State Legislature passed all the bills necessary for financing the construction and maintenance.

The total length of the bridge is 8¼ miles, 4½ miles of which are over water; it has fifty-one piers, and the cost was $77,000,000. The bridge includes the only large twin suspension bridge ever built, and the longest and heaviest cantilever bridge in the United States, and third longest in the world. It is a doubledeck structure providing for six lanes of pleasure automobiles on the upper roadway and three lanes of trucks and a double track rapid transit railway on the lower roadway.

## Annual Fees

Members are reminded that a reduction of One Dollar is allowed on their annual fees if paid on or before March 31st of the current year. The date of mailing, as shown by the postmark on the envelope, is taken as the date of payment. This gives equal opportunity to members residing in all parts of the country.

# Sir John Kennedy Medal Awarded to John G. Sullivan, M.E.I.C., Past-President of The Institute

John G. Sullivan, M.E.I.C., a Past-President of The Institute, is the recipient of the Sir John Kennedy Medal of The Engineering Institute for the year 1936.

Previous recipients of this award have been the late Colonel R. W. Leonard, M.E.I.C., G. H. Duggan, M.E.I.C., A. J. Grant, M.E.I.C., R. A. Ross, M.E.I.C., and A. H. Harkness, M.E.I.C.

This gold medal was established in commemoration of the great services rendered to the development of Canada, to engineering science, and to the profession by the late Sir John Kennedy, Past-President of The Institute. It is the highest honour which The Institute can bestow, and is given only when the occasion warrants, as a recognition of outstanding merit in the profession or of noteworthy contribution to the science of engineering or to the benefit of The Institute.

John G. Sullivan, M.E.I.C.

Mr. Sullivan was born at Bushnell's Basin, Munroe county, New York, U.S.A., on January 11th, 1863, and graduated from Cornell University with the degree of C.E. in June 1888. He commenced his engineering work with the great Northern Railway as rodman, shortly after graduating, going to Washington Territory in the spring of 1889, where he was engaged as instrumentman and assistant engineer, for the Spokane Falls and Northern Railway, until the fall of 1890 when he went to Seattle and was assistant engineer on the Pacific Extension of the Great Northern Railway, until June 1893.

Mr. Sullivan first came to Canada as assistant engineer on the Alberta Railway and Coal Company in July 1893, and in 1894 he was engaged as locating engineer on the Butte Anaconda and Pacific Railway.

In the spring of 1895 he commenced work as principal assistant engineer on the Kaslo and Slocan Railway and in 1896 he became reconnaissance engineer for the Columbia and Western Railway.

From 1898 to 1900 Mr. Sullivan was principal assistant engineer on the construction of the Columbia and Western Railway, and from 1900 to 1905 was division engineer of construction on the Canadian Pacific Railway; during this time he had entire charge of all surveys and construction on new lines built by the Canadian Pacific Railway, West of Fort William.

From 1905 to 1907 Mr. Sullivan was assistant chief engineer of the Panama Canal; his principal assignment being the excavation and disposition of waste from the Culebra Cut; but for three months while Mr. Stevens was in Washington, he was acting chief engineer in charge of all works. In the course of his duties on the Panama Canal, Mr. Sullivan designed details for the Lidgerwood Side Plough, which made the plough workable when operating flat cars with one solid side. As originally designed the plough would not work on a solid-side car in rock or boulders. His improvements increased the capacity of flat cars to 25 or 30 cubic yards, so that by reason of the long hauls involved, it was much more economical to use the plough and flat cars, than to use dump cars. This saved millions of dollars in the cost of canal excavation.

From the spring of 1907 to the fall of 1908 Mr. Sullivan was manager of construction for the Eastern Lines of the Canadian Pacific Railway, and then was promoted to the position of assistant chief engineer for the Eastern Lines, with offices at Montreal. There being no Chief Engineer, he was in charge of the Engineering Department.

In the spring of 1911 he was transferred to the Western Lines of the Canadian Pacific Railway, as assistant chief engineer, with offices at Winnipeg; and in October 1911, was made chief engineer of Western Lines. In 1915 he was appointed chief engineer of the Canadian Pacific Railway; which position he resigned in July 1918, being retained as consulting engineer up to December 31st, 1927.

Beginning with the year 1911, there was a rapid growth of railways in the West; and during some of the years of Mr. Sullivan's tenure of office, as much as fifty million dollars per annum was spent for betterments and new lines under his direction. In the construction of the Connaught Tunnel the plan of driving a centre heading was adopted. This was devised by Mr. Sullivan. With reference to this feature, the Engineering News of January 11th, 1917, made the following editorial comment:—

> "A few months back, the completion of the Rogers Pass (Connaught) Tunnel, a sound-rock tunnel, signalized the brilliant success of a radically novel method of attack in rock. The system of blasting in rings from a central pilot tunnel, a bold innovation, was the key to success. Though centuries of prior art in rock tunnelling were available, sound engineering in this case lay, in abandonment of precedent."

In 1916, the Canadian Pacific Railway Company permitted Mr. Sullivan to act as a member of the Special Board of Consulting Engineers Reporting on the design of the Aqueduct for the Greater Winnipeg Water District.

After his retirement from the Canadian Pacific Railway in 1918, Mr. Sullivan engaged in consulting work in Winnipeg, alone and later in partnership. For some years he was President of the firm of Sullivan, Kipp and Chace in that city.

Since July 1918, he has had varied experience, acting as arbitrator in labour disputes, as arbitrator between railways, and in an advisory capacity on engineering projects. Notes on some of this work are given below:—

From 1919 to 1922 he was Chairman of the Manitoba Drainage Commission, whose report was finally adopted by a Committee of the local Legislature, although not all of its recommendations were adopted by the government.

In 1919 Mr. Sullivan reported to the Minister of Public Works of Manitoba on the Economics of the proposed government Electric Power Distribution System.

During 1920 and 1921 he was retained by the Dominion Government as consulting engineer in the arbitration between the Government and the Grand Trunk Railway Company.

In 1922 he reported to the Premier of British Columbia on the physical and economic features of the Pacific Great Eastern Railway.

In 1923 Mr. Sullivan was a member of the Commission appointed by the Government of Manitoba to study and report as to the policy the Government should adopt with regard to the Provincial Hydro System.

In 1924 he reported to the Southern Railway Company on the economics and revision of that company's line between Cincinnati and Chattanooga. The result of this report was a radical change of the policy of the Southern Railway in connection with the proposed plans for this line.

In the same year he reported to Price Bros. Company on the method to be adopted in protecting their paper mill plant at Kenogami from slides which threatened the plant. Sir William Price lost his life in one of these slides. The protection works for the plant were carried out in accordance with the plans suggested by Mr. Sullivan.

In 1925 Mr. Sullivan was appointed a member of a Board of Engineers to make a joint report to the Presidents of the Canadian Pacific and Canadian National Railways, on the railway situation in the Peace river country. The result of this report has undoubtedly saved the expenditure of several millions of dollars before the development of the country would justify such expenditure.

In 1925 he was retained by a firm of consulting engineers in London, England, who had charge of a private bill proposing a vehicular tunnel between Liverpool and Birkenhead, under the Mersey river; to give testimony before a Parliamentary Committee. The applicants were successful and the tunnel has been constructed.

In 1926 he was retained by the Denver and Salt Lake Railway Company to report and advise on the practicability of ventilating the Moffat Tunnel, to permit of the operation of steam locomotives. The tunnel having been ventilated in accordance with the plans proposed by Mr. Sullivan, steam locomotives are now being successfully operated through it.

Mr. Sullivan joined The Institute, then the Canadian Society of Civil Engineers, as a Member in 1900. He served on Council in 1910 and 1918; was a Vice-President in 1911-12-13, and was President of The Institute in 1922. His interest in and services to the Winnipeg Branch have been continuous. He is a Member of the American Society of Civil Engineers, and of the American Railway Engineering Association, having been President of that body in 1918.

## Award of Medals and Prizes

### Duggan Medal and Prize

P. L. Pratley, M.E.I.C., is the first recipient of the Duggan Medal and Prize, which was established in 1935, to be presented each year from the proceeds of a donation by Past-President G. H. Duggan, D.Sc., LL.D., M.E.I.C., for the purpose of encouraging the development of the branches of engineering in which he practised. Mr. Pratley receives

**P. L. Pratley, M.E.I.C.**
*Duggan Medal and Prize*

this award for his paper entitled "The Superstructure of the Reconstructed Second Narrows Bridge, Vancouver," which was presented before the General Professional Meeting of The Institute at Hamilton, Ontario, in February 1936, and was published in the January, 1936, issue of The Engineering Journal.

Mr. Pratley was born at Liverpool, England, and received his education in that country, receiving the degree of B.Eng. with first class honours from the University of Liverpool in 1905, and the Master's degree in 1908.

Coming to Canada in 1906, Mr. Pratley was with the Locomotive and Machine Company, Montreal, as designer and draughtsman, and from 1906 until 1909 held a similar position with the Dominion Bridge Company, Montreal. In 1909-1910 he was with the Quebec Bridge Board as mathematician, designer and checker; from April to September of the latter year he was engaged with the St. Lawrence Bridge Company as designing engineer in charge of designs for the Quebec bridge, later returning to the Quebec Bridge Board during the official investigation of submitted designs. From 1910 until 1920 Mr. Pratley was designing engineer with the Dominion Bridge Company in charge of the estimating and designing office. In 1920 he served on the G.T.R. Arbitration Board, with the Department of Railways and Canals. In 1921 he became a member of the firm of Monsarrat and Pratley, consulting engineers, Montreal.

Mr. Pratley received the Gzowski Medal for the year 1934-1935 for his paper entitled "The Sub-structure of the Reconstructed Second Narrows Bridge, Vancouver."

He has long taken an active interest in Institute affairs having served as a Councillor for many years, and as a Vice-President.

### Gzowski Medal

David Boyd, A.M.E.I.C., has been awarded the Gzowski Medal for the year 1935-1936 for his paper entitled "Modern Arc Welding" which appeared in the November, 1935, issue of The Journal.

Mr. Boyd, who is assistant works manager with the Dominion Bridge Company, Montreal, has been with that firm since his graduation from McGill University in 1928 with the degree of B.Sc., first as draughtsman and checker, than as maintenance superintendent, and finally in his present position.

### Leonard Medal

The Leonard Medal (for which members of The Institute or of the Canadian Institute of Mining and Metallurgy are eligible) has been awarded this year to

**David Boyd, A.M.E.I.C.**
*Gzowski Medallist*

**L. S. Weldon**
*Leonard Medallist*

Mr. L. S. Weldon, who is resident general manager with the Geita Gold Mining Company Limited, Geita, Taneanwika, Kenya, East Africa, for his paper entitled "Mining Methods and Practice at Lake Shore Mine" which was presented before the Annual General Meeting of the Canadian Institute of Mining and Metallurgy in March, 1936, and appeared in the March 1936 issue of the Bulletin of that Institute.

Mr. Weldon graduated from McGill University in 1921 with the degree of B.Sc. in mining, and following graduation was employed with the engineering department of the Hollinger Consolidated Gold Mines Limited. In 1922-1923 he was engineer in charge of development and construction with the Nighthawk Peninsular Gold Mines Limited, and from 1924 until 1929 he was with the British Metal Corporation (Canada) Limited, as follows: 1924-1925, mine superintendent and manager, Tetreault Mine, Montauban, Que.; 1926-1927, engaged on the examination and development of properties in Canada and Newfoundland; 1928-1929, manager, Zurak Silver Lead, in Northern Nigeria, B.W. Africa; 1929, manager, Tetreault Mine, Montauban, Que. In 1930 Mr. Weldon was a member of the Empire Mining Congress to South Africa, and in the same year he became connected with Lake Shore Gold Mines Limited, being mine captain on development for two years, and on production for two years. In 1934 he was for a short time manager of St. Anthony Gold Mines Limited, returning in that year to Lake Shore Gold Mines Limited at Kirkland Lake as underground superintendent In October 1936 he accepted his present appointment.

### Plummer Medal

C. R. Whittemore, A.M.E.I.C., is the recipient of the Plummer Medal for the year 1935-1936 for his paper entitled "The Metallurgy of Metallic Arc Welding of Mild Steel" which appeared in the December 1935 issue of The Engineering Journal.

**C. R. Whittemore, A.M.E.I.C.**
*Plummer Medallist*

**Eric G. Adams, Jr.E.I.C.**
*Phelps Johnson Prizeman*

Mr. Whittemore graduated from McGill University in 1924 with the degree of M.Sc. in metallurgy, and was subsequently research chemist with the McArthur Irwin Paint Company. In 1925 he joined the staff of the Consolidated Mining and Smelting Company, at Trail, B.C., and was engaged in 1925 on experimental work in ore dressing; in 1926 he was placed in charge of the technical service department; and in 1927 he became technical librarian for the company. In 1929 he was again connected with the McArthur Irwin Paint Company, Montreal, and in 1931 was appointed metallurgist for the Dominion Bridge Company Limited, Montreal, which position he still holds.

### Students' and Juniors' Prizes

Three of these prizes were awarded this year as follows:

The John Galbraith Prize (Province of Ontario) to E. C. Hay, Jr.E.I.C., who is with the Canadian Westinghouse Company Limited, Toronto, for his paper on the "Selection of Factors of Photo Electric Cells."

**E. C. Hay, Jr.E.I.C.**
*John Galbraith Prizeman*

**Louis Trudel, S.E.I.C.**
*Ernest Marceau Prizeman*

The Phelps Johnson Prize (Province of Quebec, English) to Eric G. Adams, Jr.E.I.C., of Coverdale and Colpitts, consulting engineers, New York, N.Y., for his paper entitled "Trends in Population and Trade Affecting Transportation."

This is the third time that Mr. Adams has been the recipient of an Institute award, having received the Phelps Johnson Prize once before in 1930-1931 for his paper on "Some Economic Problems Confronting the Wider Application of Railroad Electrification in America" and the Past-Presidents' Prize for the year 1932-1933 when the subject was "The Relation of Economics to Engineering."

The Ernest Marceau Prize (Province of Quebec, French) to Louis Trudel, S.E.I.C., of the Quebec Electricity Commission, Montreal, for his "Etude Comparative sur Modèles Réduits."

### Periodicals in Institute Library

Over two hundred periodicals are received regularly by The Institute Library in Montreal, and are available for reference purposes in the reading room. Back numbers are also on file. Out-of-town members may obtain photostat copies of any articles appearing therein at a cost of thirty cents a page, plus postage, etc.

For the convenience of members we are listing these periodicals in this and in the April issue of The Journal.

Aero Digest.
Agricultural and Industrial Progress in Canada.
Air Commerce Bulletin.
The American Engineer.
American Midland Naturalist.
Anales de la Sociedad Cientifica Argentina.
Arts et Métiers.
The Beaver.
Bell Laboratories Record.
Bell Telephone Quarterly.
Boletim do Instituto de Engenharia Sao Paulo.
Building in Canada and Building Reporter.
Building Science Abstracts.
Bulletin, American Society for Testing Materials.
Bulletin de la Société des Ingénieurs Civils de France.
Bulletin, American Railway Engineering Association.
Bulletin of the Brooklyn Engineers Club.
Bulletin of Canadian Airways Limited.
Bulletin of the Canadian Engineering Standards Association.
Bulletin, Canadian Institute of Mining and Metallurgy.
Bulletin de la Société Belge des Ingénieurs.
Bulletin de la Société Française des Electriciens.
Bulletin, Edison Electric Institute.
Bulletin, The Electrochemical Society.
Bulletin, Hamburg World Economic Archives.
Bulletin, Hydro-Electric Power Commission of Ontario.
Bulletin, New Zealand Society of Civil Engineers.
Bulletin Mensuel de l'Association des Ingénieurs Electriciens Montefiore.
Bulletin Mensuel de la Société Industrielle de Nord de la France.
Bulletin of Hygiene.
Bulletin, Western Society of Engineers.
The Business Week.
Canadian Aviation.
Canadian Business.
Canadian Chemistry and Metallurgy.
Canadian Defence Quarterly.
Canadian Engineer.
Canadian Journal of Research.
Canadian Machinery and Manufacturing News.
Canadian Magazine.
Canadian Mining Journal.
Canadian Patent Office Record.
Canadian Surveyor.
Canadian Transportation.
Chemical and Metallurgical Engineering.
Chimie et Industrie.
Civil Engineering (American).
Civil Engineering and Public Works Review.
Cleveland Engineering.
Colliery Engineering—with supplement, Coal Carbonization.
Colorado Engineer.
Commercial Intelligence Journal.
Compressed Air Magazine.
Concrete.
Concrete and Quarry.
Contractors and Engineers Monthly.
Dependable Highways.
The Dominion Engineer.
Edinburgh Journal.
Electric Journal, The.
Electric Welding.
Electrical Digest.
Electrical Engineering.
Electrical News and Engineering.
Electrical Review, The.
Electrical Times.
Electrical World—and News Issue.
Electronics.
The Engineer.
Engineering.
Engineering—Notes and Extracts from.
Engineering and Boiler House Review.
Engineering and Contract Record.
Engineering and Mining Journal.
Engineering Experiment Station Bulletin.
Engineering Inspection.
Engineering News-Record.

*(To be continued in April Journal.)*

# OBITUARIES

## Henri Dessaulles, M.E.I.C.

Regret is expressed in placing on record the death in Montreal on February 21st, 1937, of Henri Dessaulles, M.E.I.C., of Shawinigan Falls, Que.

Mr. Dessaulles was born at St. Hyacinthe, Que. on December 1st, 1879, and graduated from the Ecole Polytechnique, Montreal, in 1903, with the degrees of B.A. and B.Sc.

For several years following graduation Mr. Dessaulles was engaged on the construction of the transcontinental line for the Canadian National Railways. In 1909 he joined the engineering staff of the Shawinigan Water and Power Company. From 1911 until 1913 he was employed on the construction of the Manouan river storage dams and in charge of surveys for the Gouin dam; from the latter year until his retirement from active work a few years ago due to ill health, Mr. Dessaulles was local agent and resident engineer for the Shawinigan Water and Power Company at Shawinigan Falls, Que., being in charge of real estate, house construction and general supervision.

Mr. Dessaulles joined The Institute (then the Canadian Society of Civil Engineers) as a Student on April 23rd, 1903. On January 14th, 1909, he became an Associate Member, and on May 6th, 1930, was elected a Member.

## John William Seens, A.M.E.I.C.

It is with much regret that we place on record the death at Detroit, Mich., on January 25th, 1937, of John William Seens, A.M.E.I.C.

Mr. Seens was born at Cincinnati, Ohio, on November 8th, 1881, and graduated from the University of Michigan in 1904 with the degree of B.S. (C.E.). Following graduation Mr. Seens was until 1905 a draughtsman on the staff of the Canadian Bridge Company, and then joined the staff of the city engineer of Grand Rapids, Mich. In February 1906 Mr. Seens again became connected with the Canadian Bridge Company, and remained with that firm until 1911 when he was appointed manager of the Structural Steel Company Ltd., Montreal, at that time a subsidiary of the Canadian Bridge Company. Mr. Seens became sales manager of the Canadian Bridge Company in 1918, and remained in Montreal until 1927 when he was transferred to Walkerville, Ont. He was elected a director in 1922, and vice-president in 1926. In 1927 Mr. Seens became President and general manager of the Canadian Bridge Company, and received a similar appointment from the Essex Terminal Railway. He was made president of the Canadian Steel Corporation in 1932.

J. W. Seens, A.M.E.I.C.

Mr. Seens joined The Institute (then the Canadian Society of Civil Engineers) as an Associate Member on March 12th, 1908.

## Thomas Lockwood Simmons, M.E.I.C.

Regret is expressed in placing on record the death at his home in Ottawa, Ontario, on January 19th, 1937, of Thomas Lockwood Simmons, M.E.I.C.

Mr. Simmons was born at Sheffield, N.B., on January 17th, 1872, and graduated from the University of New Brunswick with the degree of B.A. and a diploma in civil engineering in 1893. Following graduation he was engaged on bridge construction for the Bangor and Aroostook Railway, and a re-location survey north of Houlton. In 1895 he became assistant engineer on a preliminary survey of the line from Minto to Fredericton, and in 1896 he was on a location survey of the Woodstock and Centerville Railway. From 1898 to 1901 Mr. Simmons was in charge of the deepening of river reaches of Lake St. Francis; from 1901 to 1904 he was inspecting engineer with the Department of Railways and Canals. In 1904 Mr. Simmons joined the staff of the Board of Railway Commissioners as assistant engineer, becoming assistant chief engineer in 1909. On the death of George A. Mountain, M.E.I.C., in 1927, Mr. Simmons succeeded him as chief engineer of the Board of Railway Commissioners, which office he has held since that time.

T. L. Simmons, M.E.I.C.

Mr. Simmons joined The Institute (then the Canadian Society of Civil Engineers) as an Associate Member on December 21st, 1899, and became a full Member on April 24th, 1923.

## Roderick Will McKinnon, M.E.I.C.

The membership of The Institute will learn with regret of the death at Winnipeg, Man., on January 27th, 1937, of Roderick Will McKinnon, M.E.I.C.

Mr. McKinnon was born at Battleford, Sask., on November 25th, 1885. Battleford was then in the North West Territories, and Mr. McKinnon, who was the son of a Hudson's Bay Company factor, was the first white child born in that city. Mr. McKinnon studied at Dalhousie University from 1905 until 1908, and from 1908 until 1910 was an assistant on location with the Canadian National Railways. In 1910-1912 he was location engineer with the same Railway.

In 1912 Mr. McKinnon joined the staff of the Manitoba Public Works Department, and was assistant engineer in charge of the construction of the sewers and water supplies for the new agricultural college then being constructed in Manitoba. In 1913 he joined the staff of the Reclamation Branch as district engineer. In 1924 Mr. McKinnon became right-of-way agent and assistant chief engineer, and later in the year was made Commissioner of Northern Manitoba, which position he occupied until August 1925. From that date until 1930 he again acted as right-of-way agent and assistant chief engineer for the Reclamation Branch of the Department of Public Works, and on June 15th, 1930, following the death of H. A. Bowman, M.E.I.C., was appointed Chief Engineer of the Reclamation Branch, which position he occupied continuously until his death.

For the past two years, Mr. McKinnon was on the engineering committee in charge of the sewage disposal plant of the Greater Winnipeg Sewerage System.

Mr. McKinnon joined The Institute as an Associate Member on November 27th, 1917, and became a Member on March 6th, 1936.

### Robert Wood, A.M.E.I.C.

It is with deep regret that we place on record the death at Montreal on February 7th, 1937, following a short illness, of Robert Wood, A.M.E.I.C., of Quebec.

Mr. Wood was born at Kilmarnock, Scotland, on May 12th, 1902, and was educated in this country, graduating from the Montreal High School in 1919 and from McGill University in 1924 with the degree of B.Sc.

Following graduation, Mr. Wood was a student engineer with the Shawinigan Water and Power Company until 1925, when he became assistant chief engineer of the Quebec Power Company and the Quebec Railway Light and Power Company. In 1927 Mr. Wood was appointed superintendent of the Power Division of the Quebec Power Company, being in full charge of generation, transmission and distribution in the company's territory. In 1929 his ability was recognized by his selection as executive assistant of the president of the Quebec Power Company, his duties including the analysis of engineering and economic problems affecting all divisions of the company. He held that office up to the time of his death.

Mr. Wood was actively associated with the Junior Board of Trade of Quebec, and was past-president of that organization. He was an active member of the McGill Graduates Society (Quebec Branch), the Kent Golf Club and the Winter Club of Quebec.

Mr. Wood joined The Institute as a Student on March 22nd, 1921, and transferred to the class of Associate Member on May 18th, 1934.

## PERSONALS

### J. A. McCrory Vice-President of The Institute

J. A. McCrory, M.E.I.C., vice-president and chief engineer of the Shawinigan Engineering Company Limited, was elected vice-president of The Institute for 1937-1938 at the Annual General Meeting held in Montreal on January 29th, 1937.

Mr. McCrory graduated from Pennsylvania State College in 1907 with the degree of B.Sc. in mechanical engineering, and, coming to Canada in 1910, located in Toronto, where he was engaged on the design and construction of the London Hydro sub-station and in general building work. In 1912 he moved to Montreal, and for four years was employed on the design and supervision of reinforced concrete construction. Mr. McCrory joined the staff of the Shawinigan Water and Power Company in 1916 as designer, and on the formatation of the Shawinigan Engineering Company Limited in 1918, was appointed office engineer. He was subsequently engaged on the investigation and design of a large number of hydro-electric developments for the Shawinigan Water and Power Company and others, and in 1935 he received his present appointment.

Mr. McCrory has taken an active interest in the affairs of The Institute since he became an Associate Member in 1921 and a Member in 1926, having been chairman of the Montreal Branch in 1929. He represented that Branch on the Council of The Institute during the years 1930-1935.

J. A. McCrory, M.E.I.C.

Mr. McCrory is a member of the Corporation of Professional Engineers of Quebec, the Canadian Engineering Standards Association, the Canadian Electrical Association and the American Society for Testing Materials.

A. O. Wolff, M.E.I.C., Divisional Engineer, with the Canadian Pacific Railway Company, at London, Ontario, was elected chairman of the London Branch of The Institute for the current year, at the annual meeting of the Branch held recently.

Professor A. E. Macdonald, M.E.I.C., is now chairman of the Winnipeg Branch of The Institute. Professor Macdonald is professor and head of the department of civil engineering at the University of Manitoba, Winnipeg, Man.

N. W. Kershaw, S.E.I.C., is now assistant manager of the Drummondville, Que., plant of the Eagle Pencil Company. Mr. Kershaw graduated from the University of Saskatchewan in 1933 with the degree of B.Sc., and from October of the same year until May, 1934, he was instructor in the mechanical engineering laboratory of the same university. Mr. Kershaw was subsequently with the Dominion Oilcloth and Linoleum Company Ltd., at Montreal, and in 1935 joined the staff of the Eagle Pencil Company as mechanical engineer.

Horace L. Seymour, M.E.I.C., has again been retained as consultant for the Town Planning Commission of the City of Saint John, New Brunswick. Saint John is now taking advantage of the provisions of the Town Planning Act of New Brunswick drafted by Mr. Seymour which was passed by the provincial legislature last year. Information has been collected, traffic counts taken, numerous studies have been made, and maps on a large scale prepared showing the information in a graphical form easily understood by the public as well as Commission and Council members. A Major Street By-law and Map have been prepared, and the public will be consulted shortly about these proposals.

R. G. Watson, A.M.E.I.C., has been appointed by Edmonton, Alberta, City Council as superintendent of the municipally-owned power plant.

Mr. Watson came to this country from Scotland in 1912, and from that time until 1924 was mechanical superintendent and chief engineer of power with the Nova Scotia Steel and Coal Company and the British Empire Steel Corporation. In 1924-1929 he was chief engineer with the St. John Dry Dock and Shipbuilding Company. In 1929 Mr. Watson was chief draughtsman with R. A. Ross and Company, engaged on the design and supervision of installation of tube generator and auxiliaries, and from 1929 until 1932 he was mechanical engineer supervising all mechanical work on the building of the Beauharnois canal and power house. From 1932 to 1933 he was designing engineer with R. A. Ross and Company. In 1933 Mr. Watson entered private practice as a consulting engineer in Toronto as a member of the firm of Watson and Ferguson.

#### H. S. Carpenter, M.E.I.C., New Vice-President of The Institute

At the Annual General Meeting of The Institute held in Montreal on January 29th, 1937, H. S. Carpenter, M.E.I.C., Deputy Minister, Department of Highways of the Saskatchewan Government, Regina, Sask., was elected a Vice-President for the years 1937-1938.

Mr. Carpenter graduated from the University of Toronto with the degree of B.A.Sc. in 1898, and was subsequently in charge of an assay office at Sudbury, Ontario. In 1899 he practised as an Ontario Land Surveyor at Collingwood, Ontario, and in 1900 became assistant engineer for the Department of Railways and Canals on the Yukon Railway exploration. From 1901 until 1905 Mr. Carpenter was an assistant engineer with the same Department on the construction of the Trent Canal. In 1905 he entered the service of the Government of the Province of Saskatchewan, and since that time has filled the following offices: 1905-1906, district engineer and surveyor, Department of Public Works; 1907-1908, Director of Surveys; 1909-1910, Superintendent of Highways; 1911-1912, Acting Deputy Minister and Chief Engineer, Department of Public Works; 1913-1914, Superintendent of Highways with Board of Highway Commissioners; 1915-1917, Acting Chairman, Board of Highway Commissioners and in the latter year, Mr. Carpenter received the appointment which he still holds.

H. S. Carpenter, M.E.I.C.

Mr. Carpenter became an Associate Member of The Institute in 1904, a Member in 1922, and a Life Member in December, 1934. He has taken an active interest in Institute affairs, and represented the Saskatchewan Branch on the Council during the years 1921-1922 and 1923.

## Recent Additions to the Library

### Proceedings, Transactions, etc.

Institution of Mechanical Engineers: Proceedings, 1936.
American Institute of Electrical Engineers: Transactions, 1936.
Junior Institution of Engineers Inc.: Transactions, 1935-1936.

### Reports, etc.

*Canada, Dept. of Mines, Mines Branch:* Investigations in Ore Dressing and Metallurgy, January to June, 1935.
*American Association of Railways:* American Railway Signaling and Practices, Chapter XXII.
*Toronto Harbour Commissioners:* Annual Report, 1935.
*McGill University:* Annual Report, 1935-36.
*Canada, Bureau of Statistics:* The Highway and Motor Vehicle in Canada, 1935.

### Technical Books, etc.

Procedure Handbook of Arc Welding Design and Practice, Lincoln Electric Company, Cleveland, Ohio.
Road Curves for Safe Modern Traffic, by F. G. Royal-Dawson. (*E. and F. N. Spon Ltd., London.*)
Timber Design and Construction, by Jacoby and Davis. (*John Wiley and Sons, New York.*) (*Renouf Publishing Company, Montreal.*)

## BOOK REVIEWS

### Procedure Handbook of Arc Welding Design and Practice

*The Lincoln Electric Company, Cleveland, Ohio, U.S.A. 1936. 4th edition. 5¾ by 8¾ inches. $2.00. Leather.*

This volume is divided into nine parts, Part 1 covering welding methods and equipment, including forge welding, thermit welding, resistance welding, arc welding, etc. Part 2 is on the technique of welding, and includes weld dimensions, strength of welded joints, study of stress distribution in welded joints, contraction, distortion and residual stress and so forth. Procedures, speeds and costs for welding mild steel are dealt with in Part 3, with Part 4 covering the structure and properties of weld metal. Part 5 covers the weldability of metals, including factors affecting weldability, high tensile steels, chrome-molybdenum steel, chrome-nickel steels, high carbon steel, etc. Part 6 deals with designing for arc welded steel construction of machinery and gives a comparison of rolled steel and cast iron and their limitations as applied to machine design, design of levers, clevices, pins, crankshafts, bases and so on. Designing for arc welded structures is covered in Part 7, and some of the advantages of arc welded design over riveted design are given. Reinforcement of columns, beam connections, welds and calculations for continuous beam action, reinforcement of columns, etc., are also dealt with. Part 8, which contains 201 pages and 353 illustrations, shows some typical applications of arc welding in manufacturing construction and maintenance.

### Thermodynamic Properties of Steam

*By Joseph H. Keenan and Frederick G. Keyes. John Wiley and Sons Inc. New York (Renouf Publishing Company, Montreal). 1936. 7½ by 10¼ inches. $2.75. 89 pages. Cloth.*

Reviewed by Professor C. A. Robb, M.E.I.C.*

This new book has been prepared by a mechanical engineer with experience of turbine design and a physical chemist having a fine background of research on steam properties. The combination augurs well for this type of literature in the future. With its enlarged pressure and temperature range, improved accuracy, its table extending continuously from vapour to liquid states above the critical point, an international table, and the addition of auxiliary data and charts, it can hardly be considered as merely another edition of an earlier work.

These tables constitute an indispensable tool for the mechanical engineer and others who aspire to accurate heat balance calculations, particularly in the field of thermal power.

The range of pressure to 5,500 lbs./in.$^2$ and of temperature to 1,600 degrees F. has been extended beyond that of the Keenan tables of 1930, publication of which served to stimulate researchers to find common ground and reduce tolerances assigned to the skeleton table resulting from the international conference on steam properties of 1934.

A comparison of the 1936 tables and Mollier chart shows deviations in the 1936 chart, from the values in the corresponding tables, somewhat greater than for the 1930 (Keenan) chart in the case of the enthalpy, and considerably less for the entropy, over the pressure range 400-3,000 lbs./in.$^2$ with temperatures of 700-1,000 degrees F. Discrepancies in enthalpy values in the 1936 chart for the above conditions are of the order of +0.1 to +0.9 B.t.u. per pound. The corresponding differences in the 1930 chart are from −0.3 to +0.2 B.t.u. per pound. Entropy values show differences of −.0001 to +.0005 B.t.u. per degree F. per pound in the 1936 chart as against −.0004 to +0010 for the 1930 chart.

A comparison of the new and more accurate tables of 1936 with the older tables in the above pressure-temperature area shows the important modifications which have resulted from the later studies. Enthalpy values have been reduced by as much as 0.4 to 4.4 B.t.u. per pound and entropy values have been changed by amounts varying from −.0249 to +.0033 B.t.u. per degree F. per pound.

The preface contains a fine example of international co-operation in this important field and the review of fundamental thermodynamics preceding the tables will be appreciated by those who have been unable to keep in close touch with the various researches. This, with the bibliography, will go far in establishing the integrity of the whole effort which, in the opinion of the reviewer, is timely, worth doing and well done. It is unfortunate that in so representative a bibliography the name of Professor H. L. Callendar is omitted, although reference to his work is included in the text.

A Mollier chart for mercury vapour might be included with advantage in a later edition.

The book is an important contribution to engineering literature and the authors and publishers are to be congratulated on its production.

*Professor of Mechanical Engineering, University of Alberta, Edmonton, Alberta.*

## A Survey of the Present Organization of Standardization—National and International

A survey of the Present Organization of Standardization—National and International, published by the Central Office of the World Power Conference, 36 Kingsway, London, W.C.2, at a cost of 3/6 net, plus 2d postage, contains the first authoritative compilation of facts regarding national organization of standardization in thirty-two countries: Argentine Republic, Australia, Austria, Belgium, Canada, China, Czechoslovakia, Danzig Free City, Denmark, Egypt, Estonia, Finland, France, Germany, Great Britain, Hungary, Indian Empire, Irish Free State, Italy, Japan, Jugoslavia, Netherlands, New Zealand, Norway, Poland, Roumania, Spain, Sweden, Switzerland, Union of Socialist Soviet Republics, Union of South Africa, United States of America.

In the section on International Standardization, the organization, constitution, procedure and field of work of the two international standardizing bodies, The International Electrotechnical Commission (I.E.C.) and The International Federation of the National Standardizing Associations (I.S.A.) are described in detail. There are also notes on the International Association for Testing Materials (I.A.T.M.) and the International Commission for Testing Electrical Installation and Wiring Equipment (I.F.K.).

Five appendices list respectively the Advisory Committees of the I.E.C. publications issued by the I.E.C. and Technical Committees of the I.S.A., summarize the present organization of National Standardization and give a list of the abbreviated designations of International and National Organizations described in the Survey.

## Lafarge Aluminous-Cement Refractory Concrete

The aluminous cement, known as Ciment Fondu, was first produced in France in 1908, was perfected commercially in 1918, and was introduced into England in 1923. Since 1926, the material has been manufactured at the Fondu Works, West Thurrock, Essex, and has acquired a deservedly high reputation among contractors, engineers and builders. One of the newer applications of the material is its use, in conjunction with refractory aggregates, for the production of refractory concrete. Briefly, this concrete is produced by the bonding of pieces and particles of a refractory material with Ciment Fondu, which cement, it is pointed out, is itself refractory. The concrete, when it has set and hardened, is claimed to possess the physical properties of strength and hardness of ordinary aluminous-cement concrete and also the property of immunity from attack by sulphur-containing gases. The degree of refractoriness of the concrete and its strength under load at high temperatures, it is, however, emphasized, are functions of the properties of the refractory materials used in making the concrete and of the amount of cement incorporated in the mix. While the proportions of the ingredients will vary with the nature of the work involved, a 3:2:1 mix is suggested for refractory concrete for general purposes. The three parts of coarse aggregate consist of ¾-inch to ⅛-inch pieces of firebrick, and the two parts of fine aggregate of grog particles from ⅛ inch down. For refractory mortar the proportions of fine grog to one part of the cement, may range from 2½ parts to 4 parts. For higher refractoriness such products as sillimanite, chrome or chrome-magnesia materials are employed.

Speaking generally, the concrete is stable under load at temperatures up to 1,300 degrees C. and has a melting point of about 1,450 degrees C. The material, however, can be used at temperatures up to 1,600 degrees C. when chrome or chrome-magnesia aggregate are employed. Among other advantages, the material is claimed to be ready for use twenty-four hours after placing into position, to require no prefiring, to have no appreciable drying shrinkage or after-contraction, and to be approximately of the same size at working temperatures as when originally moulded. It is also interesting to note that the thermal conductivity of the concrete is stated to be less than that of the firebrick employed for its production and hence that the material possesses a certain insulating value. The refractory concrete is non-spalling, and it will withstand wide and sudden fluctuation of temperature in service.

The properties of the material and some account of the research work carried out upon it during the past five years are contained in a handbook recently issued by Messrs. Lafarge Aluminous Cement Co. Ltd.—*Engineering.*

# CORRESPONDENCE

THE EDITOR,
THE ENGINEERING JOURNAL.

DEAR SIR,

At the recent Annual Meeting all the Proposals of the Committee on Consolidation were approved. This result is not necessarily the opinion of the membership of The Institute at large, though it may have an influence on the voting of members when they cast their ballots. The question of approval of these proposals by the members is of such vital consequence to The Institute that a simple exposure of the present situation upon which each member will be called on to vote in the near future seems not only warranted but essential.

By reason of the form of the ballot paper, the fundamental question as to how Consolidation should be effected is liable to be masked by alternatives in respect to detail. Therefore, Mr. Editor, I beg space in The Journal as the best medium of expression to the membership body to present a brief analysis of some of the fundamental changes in the character of our Institute which would follow the adoption of the recommendations of the Committee on Consolidation.

1. *Admission to Corporate Membership.*

| (a) As Proposed by Committee on Consolidation. | (b) As at Present. |
|---|---|
| In future in any province where the Provincial Association becomes "component," to become a corporate member of The Institute, one must first be, or become, a member of a Provincial Professional Association. | Admission to The Institute is by application and depends upon the professional qualifications and experience and personal character of the applicant. |

According to 1 (*a*) above, membership in The Institute requires *only* that the applicant be a member of a Provincial Professional Association. The qualifications for membership in these associations is admittedly low; in Quebec Province graduation from an engineering college without any other qualification is sufficient.

Being created by Provincial legislation there must be the possibility of admission to membership in the Provincial Associations for reasons of politics.

Per contra, (*b*) above, membership in The Institute as at present is based solely on academic, professional and personal qualifications of a much higher standard than that required by the Provincial Associations, and is not, nor ever has been, influenced by political considerations.

The proposal in (*a*) requires that those engineers not required by law to become registered in Provincial Associations will have to be so registered in order to join The Institute as corporate members. Registration in any Provincial Association is a technical requirement only—there are in general no educational or engineering service features furnished by the Provincial Associations to their members. There is no conclusive reason why the obligation of registration should be imposed on that type of engineer not legally required to register. The only reason why such engineers should join a Provincial Association is, strangely enough, that by so doing, and only by so doing, may they become corporate members in The Institute. This would establish a peculiar anomaly; to become a member of The Institute one must first become a member of an organization whose standards of admission are lower than those of The Institute, and no other qualifications for membership in The Institute are then required.

2. *Grade of Membership.*

| (a) As Proposed by Committee on Consolidation. | (b) As at Present. |
|---|---|
| In future there is to be but one grade of corporate member | Associate Members and Members, etc. |

The proposal in 2 (*a*) above establishes all corporate members of The Institute as of equal rank, whether they be prominent, responsible and experienced, or merely a graduate product of an engineering college.

The present classification of membership in The Institute (2 (*b*)) establishes that an Associate Member has some engineering status and that a Member has senior qualifications and responsibilities in the engineering world.

3. *Institute Revenue.*

(Actual operating deficit in 1936 was $1,114)

| (a) Estimated as resulting from Proposals of Committee on Consolidation. | (b) Estimated under present Constitution. |
|---|---|
| At the Annual Meeting the Chairman of the Committee on Consolidation quoted an estimated deficit under these proposals from the table shown on page 546 of the December Journal. This estimate shown in the table varies from $2,291 to $2,515, depending upon the assumptions. | The Finance Committee of The Institute is as usual preparing a balanced budget for 1937. |

The Committee on Consolidation have undoubtedly worked hard and have gone to great lengths to produce the present proposals. Their work has exposed, however, that the Engineering Profession in Canada, as represented by The Engineering Institute and by the Provincial Associations, is divided into two groups having distinctly different points of view respecting the manner of Consolidation. Practically the whole representation favoured consolidation as a principle. One group, however, favours the manner proposed in detail by the Committee, the other favours a consolidation that does not destroy The Institute in its present form and with its present ideals. Within the first group there appear to be those who favour the Provincial Associations regardless of any effects on The Institute. Hence there is another alternative as follows:—

4. *Constitution of The Institute.*

| | |
|---|---|
| (*a*) As Proposed by the Committee on Consolidation. | (*b*) As Desired if Present Autonomy of The Institute is to be preserved. |

The organization as proposed in 4 (*a*) can quite easily result in The Institute being controlled and managed by those that favour the interests of the Provincial Associations regardless of the present ideals and objectives of The Institute. This point of view has actually been expressed in writing by the President of the Dominion Council of Professional Engineers in a letter dated from Saint John, N.B., November 11th, 1936, addressed to E. A. Wheatley, Vancouver, B.C. In this letter Mr. Kirby says, " . . . I believe we have the door already opened a way and all we have to do is to place our foot in the opening and keep it there until we can swing it wide open. This is because the Associations, if they accept the present proposals and *make use of them* can dominate The Institute . . . " "Future By-law changes for The Institute would be voted on by ALL Association Members, vastly outnumbering non-Association Members, and the whole set-up of The Institute depends on its By-laws." And in a memorandum attached to that letter he writes further—" . . . the Association Members (would) control the personnel of the Council and can require it to do what they desire... the By-laws of The Institute can be made to conform fully to the requirements of the Association Members." And again, "With (the proposed) representation on Council of The Institute a nucleus is set up that is strongly favourable to the Association. If the present Council of The Institute is not willing to grant favourable terms... it may be necessary to await the next Plenary Meeting (where) there is an assured majority, plus the eight Association representatives."

Thus, the deliberate desire of this group is to gain control of The Institute, not to further its present ideals but apparently to proceed along lines not hitherto exposed by the Committee on Consolidation in their portrayal of the objectives of the Consolidation movement. The proposals 4 (*a*) "have already opened the door" for the complete absorption of The Institute and the dictation of its constitution and policy by this group which cannot with consistency claim to value the present ideals of The Institute. With the policies of such a group dominating Council, indiscriminate revision of The Institute's By-Laws to an unlimited extent is possible in the future.

On the other hand, (under 4 (*b*)) there are members with the true interest of The Institute at heart, who desire a consolidation without these hazards. These persons believe that use can be made of the valuable work of the Committee, together with further efforts towards a consolidation which will not affect The Institute adversely nor jeopardize its standing, ideals and traditions.

Mr. Editor, in view of the grave decision that must be made by the membership body by ballot, I need not apologize for the length of this letter nor for the valuable space in The Journal it will occupy. I have tried to confine my remarks to facts. I am not attempting to express a personal viewpoint though this cannot but be apparent. I am on the other hand making an impersonal effort to define clearly the possible results accruing from the decision of the membership body. If the proposals of the Committee on Consolidation are approved I can see the dangers outlined above. If these proposals are rejected then consolidation will be delayed. In the first case I fear The Institute as such will be jeopardized. In the second case we will not have committed ourselves to a possibly intolerable and irrevocable situation, and will still be able to pursue the principle of consolidation—a principle which, if applied as it can be applied, is not inconsistent with the ideals of The Institute as quoted on the title page of every issue of The Journal.

Yours faithfully,

T. C. Thompson, A.M.E.I.C.

4870 Cote des Neiges Road,
Montreal.
6th February, 1937.

## The James Watt International Medal

The first award of the James Watt International Medal by the Institution of Mechanical Engineers (Great Britain) has been made to Sir John A. F. Aspinall, well known railway engineer and administrator.

The Medal was established by the Council of the Institution at the time of the celebration in 1936 of the Bicentenary of the birth of James Watt. It is to be awarded biennially with the co-operation of mechanical societies in leading industrial countries throughout the world for outstanding achievements in mechanical engineering.

# BRANCH NEWS

## Border Cities Branch

*J. F. Bridge, A.M.E.I.C., Secretary-Treasurer.*
*F. J. Ryder, Jr.E.I.C., Branch News Editor.*

After the regular dinner meeting held at the Prince Edward hotel, on Friday evening, January 22nd, 1937, the twenty-three persons present listened to a talk by one of its own members, S. E. McGorman M.E.I.C.

### The Vagaries of Population

By means of a large graph, Mr. McGorman showed how the world's population had remained fairly constant from the time of Julius Caesar (54 B.C.) to the time of Henry VIII, a period of about seventeen hundred years. Then the curve of the graph became more vertical. The ravages of cholera, the black death and smallpox had kept the curve level, but with the beginning of medical science these diseases were controlled and gradually the population increased. Wars have not been such a big deterrent in checking population increases as people imagine. For Europe at the present time has 25,000,000 more people than at the outbreak of the Great War of 1914.

Mr. McGorman sees little difference in the Communistic and Fascist controlled countries such as Japan, Russia, Germany and Italy. They are similar in that a small group controls the country. All these countries are endeavouring to increase their population, but Russia is the only one that has sufficient territory on which to support an increase in population. The labour systems in these countries are similar in that they are under government control, the difference being that Russia has a "good" Communist in charge at each plant resulting in poor production. The other countries allow the industries to remain in the hands of private management, generally resulting in good production.

However, the democracies are voluntarily reducing their population. Most of the births are occurring in the lower classes which either cannot work or are already state charges. The labour policies seem to be to try to place the minimum wage above the best average wage, and no country can afford to do this.

The present tendency of a good number of Canadians is to shut their eyes to any future wars in which England may become engaged. However, with Canada's population just about at a standstill, England's protection is needed as it is all which stands between Canada and the rest of the world.

O. Rolfson, A.M.E.I.C., and A. J. M. Bowman, A.M.E.I.C., moved a very hearty vote of thanks to Mr. McGorman for his enlightening talk.

## Halifax Branch

*R. R. Murray, A.M.E.I.C., Secretary-Treasurer.*
*C. Scrymgeour, A.M.E.I.C., Branch News Editor.*

The regular monthly meeting of the Halifax Branch of The Engineering Institute of Canada took place on Thursday, February 18th, 1937, at the Halifax hotel, with John R. Kaye, A.M.E.I.C., chairman of the Branch, presiding.

As a means of stimulating increased interest in these meetings the council provided a splendid musical entertainment which was presented during the dinner at the first part of the evening's programme and following which, the chairman introduced the speaker for the evening, Major John S. Roper, Member of the Nova Scotia Public Utilities Commission, who gave a very interesting and particularly amusing address on "The Engineering Profession as Viewed by the Legal Profession."

Following the address a general discussion took place with a number of the members expressing their views in rebuttal to the speakers' remarks and all of which provided continued interest and much amusement.

## Lethbridge Branch

*E. A. Lawrence, S.E.I.C., Secretary-Treasurer.*

### Electric Power Engineering

The Lethbridge Branch of The Engineering Institute of Canada held their regular dinner meeting in the Marquis hotel on Saturday night, January 16th, 1936, with P. M. Sauder, M.E.I.C., chairman. Mr. H. Randle of the Calgary Power Company, Calgary, was the speaker, taking for his subject, "Electric Power Engineering, Achievements, and Operating Facts."

The first part of the meeting after recess was taken up with business and correspondence on the Semicentennial Year and Consolidation, after which Mr. Randle began to speak.

He said that there are two kinds of engineering achievement: that, resulting from imaginative or analytical thinking, and that, resulting from new and improved materials or methods of manufacture. Both types may be seen in the development of alternating current for transmission. Although alternating current and the transformer were known to Faraday and others of his time, direct current was used almost exclusively, until George Westinghouse in 1886 became impressed with its possibilities and pushed its development. The invention of the induction motor for alternating current by Telsa in 1888 gave greater impetus to the movement and alternating current is practically universal today. And again for example, the incandescent lamp. Edison had trouble getting patents for his first lamps since others had had the same idea. However since their inception lamps have improved continuously, and in the last decade alone the efficiency has increased 25 per cent while the cost has decreased 60 per cent.

Mr. Randle then spoke of the transmission of power. It is interesting to note that the first proposals to draw power from Niagara Falls were to use compressed air for the distribution of that power. Finally, however, alternating current was decided on, at a frequency of 25 cycles per second. This is still in use but is not so satisfactory as the 60-cycle current used in most other places. As the generation of power became centralized at large stations and distribution systems became larger, many problems arose. Costs of lines had to go down, and today we find ten to fifteen structures to the mile as compared to fifty to sixty formerly used. Aluminum has replaced copper as the conductor. These increased spans however, meant higher wire tensions, which in turn caused vibrational stresses at the point of support, in countries much affected by wind. These stresses were overcome by the use of armour rods at the point of support and by the use of springs and rods as dampers.

These large generating plants and distribution systems must deliver current as continuously as possible, and at the correct voltage, that is, they must be stable. The problem is acute, and Mr. Randle described apparatus and methods in detail used to overcome such difficulties as inter-connection of plants, remote control of sub-stations, remote metering, interchange of load, flicker on long lines, and protection against lightning. A few remarks about electronics, photo-electric cells, and their many uses, concluded Mr. Randle's talk.

Two films were then shown which were very much enjoyed. A vote of thanks was moved to the speaker by J. M. Campbell, A.M.E.I.C., and the meeting closed with "God Save the King."

## London Branch

*D. S. Scrymgeour, A.M.E.I.C., Secretary-Treasurer.*
*Jno. R. Rostron, A.M.E.I.C., Branch News Editor.*

The annual dinner meeting and election of officers of the London Branch of The Institute was held on January 20th, 1937, at the Richmond Street Armouries as guests of the Military Engineers Association.

The speakers of the evening were P. L. Pratley, M.E.I.C., of the firm of Monserrat and Pratley, Montreal, and R. L. Dobbin, M.E.I.C., General Manager, Public Utilities Commission, Peterborough, Ontario.

About sixty-four members and guests sat down to a substantial dinner provided by the Branch, and showed their appreciation by doing full justice to it.

As the Branch members were the guests of the Military Engineers Association, Colonel Ross, former commander of the First Divisional Engineers' Corps, took the chair for the opening of the meeting, and welcomed the members of the Branch to the Officers' Mess, reminding them that they might join the Military Engineers Association for a small fee. He then called upon Brigadier General Stewart, Officer Commanding Military District No. 1, who addressed the meeting, and extended a welcome to all present.

Mayor Kingsmill then expressed his pleasure at being invited to attend the gathering, and in the course of his remarks referred to the difficulty often experienced by public works officials, whether engineers or otherwise, in carrying out their work properly and adequately when interfered with by others who, although in authority, were unskilled in the nature of the work on hand and also in many cases the funds necessary for the job were curtailed. These influences were not desirable and were likely to impair the efficiency of the work.

Colonel Ross then vacated the chair, which was taken by Jas. Ferguson, A.M.E.I.C., chairman of the Branch. After a short address in which he thanked the officers for their courtesy, he called upon the first speaker of the evening.

Mr. Pratley opened by observing the happy union of the Military Engineers Association and that of the London Branch and referred to the similar association of the Royal Engineers with the Institution of Civil Engineers in London, England.

He quite agreed with the remarks made by Mayor Kingsmill and enlarged upon them. In several cases in his experience such interference had given considerable trouble. He pointed out the system largely adopted in Canada, of getting the fabricating firms to design as well as tender for the job instead of employing a competent engineer to design the work and then call for tenders as was the practice in England. Many steel fabricating firms in Canada were objecting to this as, in the case of unsuccessful tenderers, they were put to a lot of trouble and expense for which they received no recompense.

The speaker then gave short descriptions of various works on which his firm had been engaged as designers or consultants. The suspension bridge over the St. Lawrence at Ile d'Orleans was first mentioned, also the new bridge over the Fraser river in British Columbia at which a severe washout occurred to the foundations. These were restored by driving steel sheet piling around the piles, excavating to solid ground and filling up with gravel to the underside of the substructure.

A few facts concerning the suspension of the First Narrows at Vancouver were then given. This structure is being erected by private capital at a cost of four and a half million dollars, the revenue to be earned by "toll" charges. The roadway is 29 feet wide and there are two 6-foot sidewalks. The suspension span is 1,500 feet, and slung by wire cables.

The Thousand Islands bridge is of the suspension type with a 700-foot span, 20-foot roadway and a narrow sidewalk. The proposed international bridge at Sarnia is to be of steel construction with cantilever arms supporting the large trusses of the centre span. There is to be a road 20 feet wide, with two sidewalks 3 feet wide each.

J. A. Vance, A.M.E.I.C., in moving a vote of thanks to Mr. Pratley for his address, expressed appreciation of his services to The Engineering Institute of Canada. The vote was unanimously carried. He also introduced Mr. Dobbin, as one of the vice-presidents of The Institute, and manager of the Public Utilities Commission of Petersborough for the past fifteen years.

Mr. Dobbin said he felt it was an honour to be invited to address this meeting as a representative of the president of The Institute. He reminded the members of the annual meeting of The Institute which was to be held shortly at Montreal and would be glad to meet the members of the Branch there. This also applied to the Semicentennial Celebrations of The Institute next June. He had intended to outline the present situation as to the proposed consolidation of The Institute and the Provincial Professional Associations but as time was getting short he would leave any talk on that matter to the business meeting which was to take place later in the evening.

E. V. Buchanan, M.E.I.C., general manager of the Public Utilities Commission, London, Ontario, being, so to speak, a business rival of Mr. Dobbin, proposed a vote of thanks to the speaker in a humorous speech which caused much merriment.

The chairman then asked the guests to retire to the entertaining room, where cards, games and refreshments were provided, while the business of the meeting was conducted.

The first business was the reading of the minutes and the auditors' report which were unanimously adopted. During and after the ballot for the election of officers for the ensuing year, a thorough discussion of the matter of consolidation was carried on; Mr. Dobbin, Mr. Pratley and Mr. Vance (Branch Councillor) giving much helpful information.

The election of officers then followed.

Mr. Ferguson, before vacating the chair, thanked the members for their co-operation during his year of office, and welcomed the newly elected chairman, A. O. Wolff, A.M.E.I.C., who said he hoped to enjoy the continued co-operation of the members, and promised to do all he could to promote the interests of the Branch.

Votes of thanks were given to the retiring chairman and to Major W. M. Veitch, A.M.E.I.C., for successfully organizing the meeting in the military quarters.

The members then joined the guests and a social evening was thoroughly enjoyed.

## Montreal Branch

*E. R. Smallhorn, A.M.E.I.C., Secretary-Treasurer*

### Junior Section Plant Visit

On the afternoon of Saturday, January 30th, 1937, the Junior Section of the Montreal Branch had an opportunity of visiting the plant of the Consumers Glass Company Limited at Ville St. Pierre.

Arrangements were made through the courtesy of officials of the company, and a most interesting inspection trip was the result. Those attending inspected the plant and equipment, including the furnaces, machine shop, bottle blowing plant and inspection room. Technical information was provided by Messrs. Morrison, DiBenga and Anglin.

### Recent Developments in Steam Heating

At the meeting of the Montreal Branch held on February 4th, H. F. Marshall, advertising manager and assistant sales manager of Warren, Webster and Company of Camden, N.J., gave an address in which he reviewed the developments of the modern steam heating system for dealing particularly with modernization and improved control of steam circulation.

J. G. Hall, M.E.I.C., was in the chair.

### Transmission Over Electric Wave Guides

Dr. G. C. Southworth, of the Bell Telephone Laboratories, New York, gave a most interesting talk before the Branch on February 11th, covering some of the newest developments in the art of radio transmission.

Prior to the meeting an informal dinner was held at the Windsor hotel.

Professor G. A. Wallace, A.M.E.I.C., was chairman.

### Junior Section

At the meeting of the Junior Section held on February 15th, two papers were presented: One by J. M. Fairbairn, A.M.E.I.C., general manager of Chas. Warnock and Company, on "Some Interesting Features of Inspection and Testing Work" and the other entitled "The Photo-Elastic Method of Stress Analysis" by Carleton Craig, S.E.I.C., lecturer, Department of Civil Engineering and Applied Mechanics, McGill University.

### Modern Highway Construction

At the meeting of the Montreal Branch held on February 18th, the Honourable Francois Leduc, Minister of Roads of the Province of Quebec, spoke on "Modern Highway Construction." Mr. Leduc referred to highway construction in general and to the special road programme of the province of Quebec.

Prior to the meeting a dinner was held at the Windsor hotel which was attended by seventy members and friends.

The chairman was J. A. McCrory, M.E.I.C.

## Ottawa Branch

*F. C. C. Lynch, A.M.E.I.C., Secretary-Treasurer.*

### Recent Progress of Organized Labour in England

At the first noon luncheon of the new year, held at the Chateau Laurier on January 21st, 1937, the speaker was W. L. Waters, C.E., M.E.I.C., consulting engineer of New York City. Mr. Waters, who has been engaged principally in transportation activities in the United States, Canada, Central America and England, spent several months recently in the Old Country studying labour conditions. His address was on "Recent Progress of Organized Labour in England" and comprised, as he explained, a summary of ideas obtained from labour leaders, business executives, and others.

J. G. Macphail, M.E.I.C., newly elected chairman, presided, and in addition head table guests included: G. J. Desbarats, C.M.G., Hon.M.E.I.C., P. M. Draper, president of the Trades and Labour Congress, G. A. Stone, of the Board of Railway Commissioners of Canada, F. A. McGregor, registrar for the Combines Investigation Act, C. W. Bolton, chief statistician of the Department of Labour, Squadron Leader A. Ferrier, A.M.E.I.C., P. Sherrin, A.M.E.I.C., R. K. Odell, B. F. Haanel, M.E.I.C., E. Viens, M.E.I.C., and Dr. R. W. Boyle, M.E.I.C.

Labour leaders in England have learned much in the past fifteen years, stated Mr. Waters. Even though at times they may talk radically for the benefit of some of their fire-eating constituents, they are following a conservative and far-sighted policy; and they are able to keep their membership in line. So long as this condition continues, organized labour cannot fail to be a powerful constructive force in English national life, and to be considered with the middle classes as the backbone of the country.

The speaker traced the history of organized labour in the Old Country since the War, with particular emphasis upon its part in transportation. Over there, he stated, labour leaders are taking a broad long-ranged view of industry in marked contrast to the continual agitation for minor concessions so prevalent in North America. The public reaction to the general strike of 1926, the sobering effect on the labour leaders of the fact that a labour ministry had the responsibility of governing the country for many years, and the realization during the depression that labour was really fighting foreign competition rather than capital, are among the more important of the reasons for this attitude.

At first labour was fearful lest the rationalization of British industries to meet external competition would result in unemployment through the shutting down of obsolete plants and the introduction of labour-saving machinery. "But they soon realized," stated Mr. Waters, "that it is better to have 100 men employed at good wages than 150 at sweat shop rates; and that once an industry becomes prosperous it will expand, so that ultimately the additional 50 men who had to go on the dole, will be re-employed at living wages. Thus we now find organized labour in England favouring rationalization of industries, consolidations and the introduction of modern machinery."

Generally speaking labour believes that such a course will ultimately permit of a shorter week and higher wages without the necessity of raising prices. It also favours unions covering a whole industry, as such permit dealing with conditions as a whole, while craft unions do not.

The Labour Party in Great Britain must not be considered as a political branch of the labour unions, remarked the speaker. "The Labour Party is strictly a political party like the Conservative or Liberal," he said, "and the labour unions are wise enough to keep themselves free from political entanglements, so that they can be in a position to demand concessions from any party."

The speaker then referred to three examples of monopoly or quasi-monopoly in the field of transportation resulting from the pressure of organized labour. The first of these was the amalgamation of the English railways into four territorial groups under private ownership and management. Through the pooling of traffic between common points this has practically eliminated rail competition though it is still subject to independent highway competition.

The second is the London Passenger Transport Board, operating a monopoly of passenger transportation for hire in the London area, with receipts pooled with the suburban railway traffic. The securities of the Board are privately owned and the properties are under a management virtually a public trust free from political interference.

The third is the government-appointed North Ireland Road Transport Board, with its securities privately owned, operating all highway passenger and freight transportation for hire, with receipts pooled with the railways. This will first be tried as a public trust selected by the existing enterprises and labour expects that ultimately the railways will be absorbed resulting in a monopoly of public transport in the territory.

Actually, pointed out the speaker, none of these is an absolute monopoly, as they are all subject to the competition of privately owned automobiles and trucks used exclusively in the owner's business or pleasure.

Organized labour in England, however, is not afraid of monopoly, either in industry or transport, as it realizes from experience the economies and the benefits to labour which result from strongly organized and prosperous consolidated properties. It is also satisfied that no monopoly, especially a public utility monopoly, can abuse its power; as if it attempts to do so, the public always develops an effective way to control conditions.

*Note.*—This paper is published in full elsewhere in this issue of The Journal.

### New Developments in Refrigeration

At the noon luncheon at the Chateau Laurier on February 11th, 1937, W. H. Cook, D.Phil., of the National Research Laboratories, gave an address on "Some New Developments in Refrigeration and Cold Storage." Dr. Cook for the past six years has been conducting investigations at the laboratories into the transport and storage of perishable foodstuffs. In June of last year he attended the Seventh International Congress on Refrigeration held at The Hague, Holland, and spent part of the summer at the Low Temperature Research Station, Cambridge University, England.

J. G. Macphail, M.E.I.C., chairman, presided and additional head table guests included: G. J. Desbarats, C.M.G., Hon.M.E.I.C., president of The Institute; Dr. H. Barton, Deputy Minister of the Department of Agriculture; Dr. R. Newton, Dr. J. B. Dabbitt, and Dr. C. A. Winkler, of the National Research Council; Col. H. O. Lawson and Major C. S. Jones, of the Department of National Defence; E. Viens, M.E.I.C., Col. R. L. Wheeler, John Murphy, M.E.I.C., and B. F. Haanel, M.E.I.C.

Dr. Cook, after mentioning that certain principles of refrigeration were known for many centuries, stated that one of the first reasonably successful shipments of meat was made on the steamship "Frigorifique" from Buenos Aires to Rouen in 1877. He then outlined modern methods of refrigeration both for stationary storage of perishables and for transport, and indicated methods for meeting some of the problems that arose.

The need for extending the storage life of commodities held in the chilled condition has recently resulted in several new methods of preservation, he stated. Among these—for those foods which can be frozen—is quick freezing and storage at low temperatures, a procedure which is not so destructive to tissues as slow freezing or temperatures just below the freezing point. The reason for this is that much smaller ice crystals are formed in the quick freezing process and maintained at the very low temperatures.

Dr. Cook elaborated upon the methods in use for obtaining and maintaining these low temperatures. He also dealt with the use of gases, particularly carbon dioxide gas, as an aid in the preservation of foodstuffs along with humidity control as well.

## Winnipeg Branch

*H. L. Briggs, A.M.E.I.C., Secretary-Treasurer.*

### The Cathode Ray Oscillograph

On February 4th, 1937, Dean E. P. Fetherstonhaugh, M.C., B.Sc., M.E.I.C., Professor of Electrical Engineering, University of Manitoba, delivered an interesting paper on the subject "The Cathode Ray Oscillograph."

After touching on the "point by point" method of analyzing electric waves, and pointing out the limitations of the Duddles type oscillographs, Dean Fetherstonhaugh went on to describe the recent types of cathode ray oscillographs or oscilloscopes, using inertialess beams of cathode rays or electrons. The beam is in each case produced by attracting electrons from a hot cathode toward an anode. The anode has a small hole in its centre; certain of the electrons carry on through this hole; these are concentrated by being passed concentrically through a hollow cylinder maintained at proper voltage; they are then deflected in one plane by being passed between parallel plates whose potential difference corresponds to the electric quantity being examined; the electrons are then deflected in a second plane at right angles to the first by being passed between parallel plates which give a time base to a trace which appears on the fluorescent screen at the end of the tube.

The speaker explained adjustments, advantages and disadvantages of the instruments, and gave several demonstrations of their use.

J. W. Sanger, M.E.I.C., expressed the feeling of the meeting in moving a hearty vote of thanks.

The meeting then proceeded with the business of the annual meeting of the Branch, reports being presented as synopsized in the February issue of The Journal.

G. E. Cole, A.M.E.I.C., 1936 Chairman of the Branch, handed the meeting over to the incoming Chairman, Professor A. E. Macdonald, M.E.I.C., who, after a few appropriate remarks, declared the meeting adjourned for refreshments.

## Competition for Scientific Papers on Arc Welding

To encourage scientific interest in the thousands of uses to which arc welding may be put, the James F. Lincoln Arc Welding Foundation has set aside $200,000, which will be awarded to persons who prepare satisfactory papers upon this subject.

To participate in this contest, it is necessary only that the papers submitted describe either the re-design of an existing machine, structure, building, etc., so that arc welding may be applied to its manufacture; or present a design (either in whole or in part) of a machine, structure, building, etc. not previously made—the description to show how a useful result, which was impractical with other methods of construction or could better be done by arc welding, is obtained.

Owners and operators of established companies specializing in welding may be entered in the competition through papers which describe the details for successfully conducting such an establishment.

Enquiries regarding this competition should be addressed to the Secretary, the James F. Lincoln Arc Welding Foundation, P.O. Box 5728, Cleveland, Ohio.

# Preliminary Notice

## of Applications for Admission and for Transfer

February 27th, 1937

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

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The Council will consider the applications herein described in April, 1937.

R. J. Durley, Secretary.

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*The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in soms branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at ths discretion of the Council, be reduced to ten years inthe case of a candid ate for election who has graduated from a school of engineering recognized by the Council. In every case ths candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of,age, and shall have been engaged in some branch of engineering for at least six years which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch ofengineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more year.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by ths Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard.

**A Student** beshallat least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by ths Council.

Hs shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which hs has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

> The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.

### FOR ADMISSION

DUGAS—JOSEPH ESDRAS ARMAND, of Montreal, Que., Born at Joliette, Que., Jan. 5th, 1907; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1932; 1928-29 (summers), and 1932-33, inspr. on gen. underground conduit systems, Electrical Commission, City of Montreal; 1933-35, sales engr., Superior Automatic Heating Co.; 1935-36, with Arthel Ltd., in charge of sales, preliminary design and complete installns. of Arthel Sunlight Apparatus; Dec. 1936 to Jan. 1937, in charge of work inspection, Imperial Oil Wharf, Montreal East, for Montreal Harbour Commissioners; At present, with Montreal Light, Heat and Power Cons., in Industrial Lighting Divn., New Business Dept.
References: A. Cousineau, A. Frigon, G. E. Templeman, A. Duperron, A. Mailhiot.

DUNNE—CHARLES VINCENT, of 56 College Ave., Ottawa, Ont., Born at Ottawa, Dec. 11th, 1907; Educ., B.Eng. (Civil), McGill Univ., 1935; 1929-30 (summers), dftsman., rodman, Boston & Maine R.R.; 1935 (summer), sub-leader, Geol. Survey, Kapuskasing, Ont.; At present, constrn. engr., E. B. Eddy Co. Ltd., Hull, Que.
References: E. Brown, A. N. Ball, D. G. McCrone, W. S. Kidd, E. D. Berry, R. DeL. French.

EDWARD—JAMES EDWARD, of Montreal, Que., Born at Glasgow, Scotland, March 14th, 1901; Educ., 1914-1937, various technical courses, including chemistry, radio, business correspondence; 1936-37, Lieut., Royal Canadian Corps of Signals; 1914-18, junior chemist, analysis of metals, ores, etc., J. T. Donald & Co. Ltd., Montreal; 1918, Jenkins Valves, design, etc.; 1918-22, Canadian Vickers Ltd., apprentice drawing office, design of steam engines, boilers, pumps and pumping systems. Checking alignments at erection of engines, etc. Propeller design and replacement. Note: Technical course in design, strength of materials, etc., during this period, under R. Ramsay, A.M.E.I.C., chief engr.; 1922 to date, with the Bell Telephone Company of Canada as follows: 1922-27, chief records checker, 1927 to date, design, estimating, mtce. of telephone plant and equipment, and at present building cable engr.
References: D. Stewart, E. Baty, G. S. Ridout, A. N. Scott.

JOHNSON—ROBERT, of 193 Waverly St., Ottawa, Ont., Born at Mountain, North Dakota, U.S.A., Feb. 22nd, 1912; Educ., B.Sc., 1933, M.Sc., 1936, Univ. of Sask.; 1934-36, part time instructor in mech. engrg. lab., Univ. of Sask.; 1935 (2 weeks), asst. on design, Ceepee Bridge, Saskatoon; 1935 (4 mos.), water resources survey, Dept. of Mines; At present, writing reports on Water Resources of Prairie Provinces.
References: J. V. Butterworth.

MARCHAND—RAYMOND, of 527 St. Clement St., Montreal, Que., Born at Valleyfield, Que., Mar. 27th, 1906; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1931; Summers, 1924, 1925, 1927, 1928, rodman, Quebec Streams Commn.; 1926, asst. geologist, Dept. of Mines; 1929 and 1930, timekpr., Collet Freres, Contractors; 1931 and 1933 (summers), asst. engr., Water Board Commn., Montreal; July 1935 to date, res. engr., Dept. of Roads, Prov. of Quebec, Quebec, Que.
References: O. O. Lefebvre, A. Duperron, A. Collet, L. Martin.

MARSTON—EWART FRANCIS, of 295 Albert St., Ottawa, Ont., Born at Caledonia Springs, Ont., Apr. 28th, 1905; Educ., 1924-26, McGill Univ., completed first year Arts; 1924-25 (summers), checker on highway contracts, 1926-27, rodman, and 1927 to date, asst. engr. on mtce. and constrn. contracts. Under the res. engr., responsible for layout, design of details and inspection of over $200,000 of new work each year, including paving, high grade revisions, reinforced concrete bridges and culverts, subway layout, etc., Dept. of Highways of Ontario.
References: R. M. Smith, A. A. Smith, W. L. Saunders, A. K. Hay, N. M. Cooke.

MARTIN—GERALD, of 1222 Seymour Ave., Montreal, Que., Born at Lachine, Que., April 1st, 1913; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1934; 1935-36, struct'l. designer, and 1936 to date, boiler designer, Dominion Bridge Company, Montreal, Que.
References: F. Newell, R. S. Eadie, A. S. Wall, A. Frigon, A. Mailhiot.

MILLETT—RALPH STRATHIE, of 146 Aylmer Ave., Ottawa, Ont., Born at Littleton, Mass., July 30th, 1899; B.Sc. (Mech.), N.S. Tech, Coll., 1923; 1923-26, fficiency engr., T. S. Simms & Co., Saint John, N.B., in charge of kiln drying of lumber and carrying out research work; 1926-29, forest products asst., Grade 2, and 1929 to date, forest products engr., Timber Mechanics Divn., Forest Products Laboratories of Canada, Ottawa, Ont. Research work, preparation of reports and publications, design of containers, design and erection of machy. necessary in research work, etc.
References: T. A. McElhanney, J. F. Harkom, W. J. LeClair, W. E. Wakefield, C. D. Wight.

MORENCY—JOHN, of Gold Park P.O., Wawa, Ont., Born at Montreal, Que., Feb. 20th, 1909; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1932; R.P.E. of Quebec; Summers 1927 and 1931, with Dept. of Roads, Quebec; 1929-30-33-34, with Quebec Bureau of Mines; 1934 to date, mine engr., Parkhill Gold Mines Ltd., Gold Park P.O., Wawa, Ont.
References: A. Mailhiot, O. O. Lefebvre, A. O. Dufresne, A. Frigon, E. Cormier, T. J. Lafreniere, P. J. Leclaire.

OGILVIE—GORDON, Lieut.-Col., C.M.G., of 170 Laurier Ave. East, Ottawa, Ont., Born at Aberdeen, Scotland, March 13th, 1878; Educ., 1895-97, Royal Military Academy, Woolwich; 1909-10, Passed Advanced Class, Ordnance College, Woolwich (Military College of Science); Member, Inst. of Engrg. Inspection, London, 1920; Commissioned 2nd Lieut., Royal Artillery, 1897; Brevet Lt.-Col., 1917, Lt.-Col., 1922; 1911-13, asst. inspr., inspection dept., Woolwich; 1913-15, inspr., inspection dept., Dept. of Militia, Canada; 1915-16, chief inspr., Imperial Munitions Board; 1916-19, deputy director and chief inspr., Imperial Ministry of Munitions, inspection dept. (Canada); 1919-36, chief inspr. of explosives, Dept. of Mines, Canada; At present, Director (Civilian) of Munitions, Dept. of National Defence, Ottawa, Ont.
References: C. Camsell, F. C. C. Lynch, L. L. Bolton, J. R. Donald, H. W. B. Swabey.

REID—WILFRID THOMAS, of Montreal, Que., Born at London, England, March 4th, 1887; 1903-08, engrg. study, W. H. Allen Son & Co. Ltd.; Assoc. Member, Inst. Mech. Engrs. (England), 1925; 1908-10, dftsman., Fairfield Shipbuilding Co.; 1910-11, dftsman., G. & J. Weir Ltd.; 1911-15, senior dftsman., W. H. Allen Son & Co. Ltd.; 1915-16, senior dftsman., Royal Aircraft Est.; 1916-21, chief asst. designer (Aircraft), Bristol Aeroplane Company, Bristol; 1921-24, chief designer (Aircraft), for same company; 1924-27, chief aeronautical engr., Canadian Vickers Ltd., Montreal; 1927-29, president and chief engr., Curtiss-Reid Aircraft Company, Montreal; 1931 to date, president, Crude Oil Engine and Engineering Co. Ltd., Montreal, Que.
References: E. W. Stedman, J. H. Parkin, J. B. D'Aeth, J. L. Busfield, F. S. B. Heward.

ROSSAERT—FERNAND EMILE NORBERT, of Montreal, Que., Born at Antwerp, Belgium, May 10th, 1901; Educ., 1920-24, completed four years out of five-year engrg. course, at the Polytschnic School, Brussels; 1921-24, asst. engr. in constrn. dept. of the Gas Company of Anvers, assting. chief engr. in mech'l., struct'l. steel and concrete designing, and 1924-26, in same dept., on struct'l. steel and concrete designing, estimating, planning of gas distribution; 1926-27, dftsman., and 1927

to date, asst. district plant engr., Bell Telephone Company of Canada, Montreal, designing, estimating and mtce. of telephone plant.
References: E. Baty, R. W. Bastable, L. G. Buck, A. N. Scott, D. Stewart.

SNAPE—JOHN BALL, of Jasper, Alta., Born at Pelsall, Staffs., England, Dec. 28th, 1888; Educ., Passed Studentship Examinations of Institution of Civil Engineers (England). 1905-08, articled pupil, F. W. Mager, A.M.I.C.E.; 1908-12, asst. engr., Walsall Rural District Council. Road constrn., bldgs. and bldg. constrn., sewerage and sewage disposal works, etc.; 1912, with Canavan & Mitchell, Constrn. Engrs., Victoria, B.C., on plans and details of a sewerage and sewage disposal plant for the Town of Kelowna; 1912-13, engrg. office, C.N.R., Victoria; Passed Prelim. Exam. for Land Surveyors of B.C.; 1913-14, surveying office of Green Bros. Burden & Co., Victoria; 1915-19, overseas service; 1919-20, in chief engr's. office, Provincial Dept. of Railways, B.C., work included plans and details for hydro-electric scheme for the Town of Squamish, B.C., designs for trestle rly. bridges, etc.; 1920-21, junior engr., Reclamation Service, Dept. of the Interior, Dominion Gov't.; May 1921, transferred to National Parks Branch, and appointed resident engineer, Jasper National Parks, holding this position to the present date. Work includes various kinds of engrg. and constrn. work such as mtce. and improvement of motor roads, locating and constructing road diversions and tote roads, mtce., design and constrn. of road bridges; maintaining and improving streets on townsite, designing and erecting various utility bldgs. for the Dept.; acting as bldg. inspr. for residences and stores built on townsite; maintaining water supply system; installing electric light distribution lines for the town and camps; maintaining street light supply system; constructing over 200 miles of standard horse trails; constrn. of 150 miles of field telephone line, etc.
References: J. M. Wardle, T. S. Mills, A. C. Wright, A. W. Haddow, J. B. Holdcroft.

SNYDER—BEVERLY WELLS, of Calgary, Alta., Born at Toronto, Ont., June 9th, 1908; Educ., B.Sc. (C.E.), Univ. of Alta., 1931; 1929 (summer), rodman and instr'man., City of Calgary, Engrg. Dept.; 1930 (summer), instr'man., Glenmore Dam Survey, City of Calgary, Waterworks Dept.; 1931-32, engr. in charge of location, levels, grades, reinforced steel and concrete placing inspection, quantity calculations, etc., filter plant unit of Glenmore project; 1932 (summer), engr. in charge of constrn. of footings for 500,000-gal. water tank, North Calgary; 1933 to date, engr., Canadian Western Natural Gas, Light, Heat and Power Co. Ltd., Calgary, and at present asst. to the vice-president.
References: A. S. Chapman, J. R. Wood, F. J. Heuperman, E. W. Bowness, R. S. L. Wilson.

WHITE—ARTHUR FLOYD, of 128 Eastbourne Ave., Hamilton, Ont., Born at St. Thomas, Ont., May 7th, 1889; Educ., 1908-11, correspondence course; 1906-08, chainman, 1908-11, dftsman., 1911-12, instr'man., M.C.R., St. Thomas, Ont.; 1912-27, instr'man., 1927-33, asst. engr., and 1933 to date, transitman, Toronto, Hamilton & Buffalo Rly. Co. Present duties equivalent to that of asst. engr., and include full charge of all bridges and bldgs.
References: R. L. Latham, R. K. Palmer, H. B. Stuart, V. S. Thompson, W. L. McFaul, E. G. MacKay, G. A. Colhoun, E. D. W. Courtice.

### FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

WIGHTMAN—JOHN FREDRICK CARMAN, of Kentville, N.S., Born at Lawrencetown, N.S., Oct. 25th, 1893; 1913-15, 2 years engrg. course, Mt. Allison Univ.; Home study and corres. courses; 1915-18, overseas service, Capt.; 1920, supt. of highways, Cumberland and Colchester Counties, N.S.; 1921-22, town engr., Amherst, N.S.; 1923-24, private practice; 1924-25, constrn. engr., 1927-30, county engr., N.S. Highways Dept.; 1930 to date, town manager and engineer, Kentville, N.S. (*A.M. 1920.*)
References: H. W. McKiel, A. R. Chambers, C. A. Fowler, K. L. Dawson, W. P. Copp, H. F. Laurence.

### FOR TRANSFER FROM THE CLASS OF JUNIOR

ANDREWS, WILLIAM EDWARD, Capt., R.C.E., of London, Ont., Born at Beamsville, Ont., Oct. 28th, 1902; Educ., Grad., R.M.C., 1924. B.Sc. (Civil), McGill Univ., 1927; 1927-29, courses at School of Military Engrg., Chatham, England; 1929-33, instructing at Royal Canadian School of Military Engrg., Halifax, N.S. Employed on engr. services and works (bldg. mtce., military camps, rifle ranges, etc.); 1933, Acting District Engr. Officer, Mil. Dist. No. 3, Kingston, Ont.; 1934-35, Acting District Engr. Officer, Mil. Dist. No. 2, Toronto; 1935 to date, District Engr. Officer, Military Dist. No. 1, London, Ont. (*Jr. 1930.*)
References: W. M. Veitch, H. L. Hayman, S. W. Archibald, C. S. Bennett, I. Leonard.

BLACKMORE—CYRIL LESLIE, of 3515 Durocher St., Montreal, Que., Born at Tilt Cove, Nfld., June 14th, 1898; Educ., B.Sc. (E.E.), McGill Univ., 1927; 1919-20, line distribution work; 1920-22, electrn., paper mill work; 1927-29, students course, and 1929-30, elect'l. engr. in charge of power house installn. at Deer Lake, for International Paper Company; 1930-31, elect'l. engr., Gatineau, in charge of elect'l. equipment; 1933 to date, president, C. L. Blackmore & Co. Ltd., electrical contractor, Montreal, Que. (*St. 1925, Jr. 1930.*)
References: C. V. Christie, C. M. McKergow, G. L. Wiggs, W. G. Hunt, J. H. Trimingham.

FOULKES—THOMAS, of Kapuskasing, Ont., Born at Liverpool, England, July 26th, 1904; Educ., B.Sc., (E.E.), Univ. of N.B., 1926; 1922 (Sept.-Dec.), compassman, N.B. Forestry Survey; Summers 1924-25, rodman and instr'man., N.B. Elec. Power Commn.; 1926-27, test dept., 1927-28, induction motor design dept., Can. Gen. Elec. Co., Peterborough; 1928-29, substation mtce. man., and 1929 to date, mtce. materials engr., Spruce Falls Power and Paper Co., Kapuskasing, Ont. (*St. 1925, Jr. 1929.*)
References: C. W. Boast, C. R. Murdoch, V. S. Foster, A. B. Gates, W. M. Cruthers.

MOSLEY—HAROLD GORDON, of 760 Mechanic St., Glace Bay, N.S., Born at Glace Bay, N.S., Mar. 16th, 1904; Educ., Passed E.I.C. Exam. under Schedule "B" for admission as Junior, Nov. 1935. I.C.S. Courses; 1920-21, mine survey dept., 1921-23, dfting. office, and 1923-28, surveyor, Dominion Coal Company, Glace Bay; 1929-30, struct'l. dfting. office, Dominion Bridge Company, Lachine, Que.; 1930-34, asst. to town engr., Glace Bay, N.S.; 1934 to date, mining engrg. dept., Dominion Coal Company, Glace Bay, N.S. (*Jr. 1935.*)
References: A. L. Hay, J. R. Morrison, M. F. Cossitt, C. M. Anson, S. C. Mifflen.

PAULSEN—RUDOLPH O., of Toronto, Ont., Born at Erickson, Man., July 13th, 1906; Educ., B.Sc. (C.E.), Univ. of Man., 1929; 1927, leveller on drainage with Manitoba Govt., Dept. of Public Works; 1928, reinforced concrete inspr. with C. D. Howe & Co. on constrn. Pool Terminal No. 7 at Port Arthur; 1929-30, detailing reinforced concrete and struct'l. steel and reinforced steel inspection on constrn. Slave Falls Development, Winnipeg Hydro-Electric; 1931, asst. to res. engr. on constrn.. Winnipeg River Bridge at Lac du Bonnet, Winnipeg Hydro-Electric; 1932 36, res. engr. on constrn. of Trans-Canada Highway, with Dept. of Northern Development of Ontario; At present struct'l. dftsman., Toronto Iron Works, Toronto, Ont. (*Jr. 1930.*)
References: J. W. Sanger, E. A. Kelly, A. E. Macdonald, G. H. Herriot, T. F. Francis, C. T. Barnes.

### FOR TRANSFER FROM THE CLASS OF STUDENT

CAREFOOT—HERBERT REGINALD, of Ottawa, Ont., Born at Floradale, Ont., Oct. 17th, 1905; Educ., B.Sc. (C.E.), Univ. of Sask., 1929. Imperial College of Science and Technology, London, England, 1935-36; 1926-27 (summers), drainage surveys and highway location; 1929 to date, General List Officer, Royal Canadian Air Forces. Variously employed technically as commanding an advanced overhaul base, and now employed as asst. in the Aircraft Development Section. (*St. 1929.*)
References: E. W. Stedman, A. Ferrier, C. J. Mackenzie, R. A. Spencer, G. R. Turner.

COLGAN—PATRICK JOSEPH, of Yarmouth North, N.S., Born at Halifax, N.S., Nov. 16th, 1908; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1934; 1934-36 (18 mos.), shop experience in various depts. of the Massey-Harris Co. Ltd., Toronto works; 1936 (5 mos.), road inspr., Milton Hersey Inspection Co. Ltd.; At present, asst. in roll repair shop and stockroom, Cosmos Imperial Mills, Yarmouth, N.S. (*St. 1930.*)
References: S. Ball, C. W. McCarthy.

DALE—JOHN CLAPHAM, of Calgary, Alta., Born at Lloydminster, Sask., Sept. 18th, 1909; Educ., B.Sc. (E.E.), Univ. of Alta., 1932; 1932-35, engrg. dept., Northwestern Utilities Ltd., Edmonton, Alta.; 1935 to date. rates, franchise, design, dfting, estimating, with the Canadian Utilities Ltd., Calgary, Alta. (*St. 1930.*)
References: J. Garrett, E. Nelson, E. W. Bowness, J. Haddin, R. S. Trowsdale.

DORE—RICHARD FRANCIS, of 16 Aylmer Ave., Ottawa, Ont., Born at Ottawa, Oct. 20th, 1908; Educ., B.Sc. (Civil), Queen's Univ., 1932; 1928, leveller, topog. survey, Dept. Interior, Ottawa; 1929-30 (summers), chainman, Man.-Ont. Boundary Survey; 1932 and 1934 (summers), student asst., geol. survey, Dept. of Mines; 1934-35, junior instructor, dept. of civil engrg., Queen's University; 1935 to date, junior topog'l. engr., Bureau of Economic Geology, Dept. of Mines and Resources, Ottawa, Ont. (*St. 1932.*)
References: J. V. Butterworth, E. M. Dennis, W. G. H. Flay, N. B. MacRostie, S. M. Steeves, W. P. Wilgar.

KELLAM—GEORGE DOUGLAS, of Calgary, Alta., Born at Montreal, Que., Feb. 23rd, 1911; Educ., B.Sc. (E.E.), Univ. of Man., 1933. One year post-graduate study in economics, extramurally; 1933-34, demonstrator, Univ. of Man., elect'l. dept.; 1934-35, asst. engr., running survey of diamond drilling, Canadian Mining Projects, Herb Lake, Man.; 1935-36, shop asst., 1936 to date, asst. engr., Canadian Western Natural Gas, Light, Heat and Power Co. Ltd., Calgary, Alta. (*St. 1933.*)
References: F. J. Heuperman, E. W. Bowness, E. P. Fetherstonhaugh, N. M. Hall, J. F. Cunningham, W. F. Riddell.

SAVAGE—PALMER ERNEST, of Montreal, Que., Born at Brandon, Man., July 20th, 1909; Educ., B.Sc., 1931, M.Eng., 1934, McGill Univ.; Studied transportation at Yale Univ., 1933-34, on Strathcona Memorial Fellowship; 1928 (summer), rly. constrn. in Alta.; 1929-30 (summers), dftsman., and 1931 (autumn), dftsman. and designer, Dominion Bridge Co.; 1932 (Feb.-Sept.), inspr. on constrn., C.P.R.; June 1934 to date, struct'l. designer, Dominion Bridge Co. Ltd., Lachine, Que. (*St. 1930.*)
References: F. P. Shearwood, E. Brown, R. E. Jamieson, F. Newell, R. S. Eadie.

WESELAKE—EDWARD JOSEPH, of 503½ Selkirk Ave., Winnipeg, Man., Born at Winnipeg, Man., June 20th, 1907; Educ., B.Sc. (E.E.), Univ. of Man., 1930; 1928 (5 mos.), topog'l. survey, Island Falls, Sask.; 1929 (5 mos.), inspr., rock ballasting, C.P.R., Kenora; 1930-31 (16 mos.), dftsman., preparation of plans, central steam heating system, Northern Public Service Corpn. At present not employed in engrg. work. (*St. 1927.*)
References: E. P. Fetherstonhaugh, W. G. Chace, N. M. Hall, C. A. Clendening, G. H. Herriot.

## New Industrial Developments in Toronto

Reflecting the general trend of improved business during 1936, the establishment of new industries in the Toronto area last year exceeded the records of both 1934 and 1935 in all three major particulars—floor space occupied, capital invested and employment created. This was the salient feature of the report of the Toronto Industrial Commission presented at its annual meeting recently by John A. Tory, president. The report showed that the Commission not only co-operated with eleven outside concerns in commencing factory operations in Toronto last year, but also assisted eight existing Toronto firms in connection with expanding their plant facilities, adding new lines of manufacture and other problems.

An outstanding feature of the report was the statistical summary of the Commission's activities since it began operations nearly eight years ago. It showed that one hundred and twenty-six new industries had been established and twenty-four manufacturing arrangements effected in the Toronto area with the assistance of the Commission. At December 31st, 1936, these one hundred and fifty industrial developments represented capital investment in plant and equipment of over $6,904,000, a gain of over $1,300,000 compared with the total a year ago; direct employment of four thousand and fifteen persons, seven hundred and forty-three more than a year ago; an annual payroll in excess of $4,000,000, an increase of $831,000 over the 1935 figure; and 1,919,390 square feet of floor space occupied, a gain for the year of over 270,000 square feet.

Directors elected to the Board included Mayor D. D. Robbins, representing the city council; the following six representing the Board of Trade—R. C. Berkinshaw, general manager of the Goodyear Tire and Rubber Company Ltd.; A. E. K. Bunnell, M.E.I.C., consulting engineer, Wilson and Bunnell; C. L. Burton, president, The Robert Simpson Company Ltd.; Ivor R. Lewis, staff superintendent, the T. Eaton Company, Ltd.; F. D. Tolchard, general manager, Board of Trade, and John A. Tory, supervisor, Sun Life Assurance Company of Canada; three representing the Toronto Branch of the Canadian Manufacturers' Association—A. B. Cooper, M.E.I.C., general manager, Ferranti Electric Limited; A. Ross Robertson, A.M.E.I.C., manager, Dominion Bridge Company Ltd., and F. E. Waterman, general manager, Toronto Brick Company Ltd.; and the following four representing public bodies of the city of Toronto—E. M. Ashworth, general manager, Toronto Hydro-Electric System; J. E. Ganong chairman, Toronto Harbour Commissioners; D. W. Harvey, general manager, Toronto Transportation Commission, and Elwood A. Hughes, general manager, Canadian National Exhibition Association. C. L. Burton was elected honorary president of the Commission; John A. Tory, president, and A. B. Cooper, F. E. Waterman, and E. M. Ashworth, vice-presidents.

—*Toronto Industrial News Bulletin.*

## EMPLOYMENT SERVICE BUREAU

The Service is operated for the benefit of members of The Engineering Institute of Canada, and for industrial and other organizations employing technically trained men—without charge to either party.

*All correspondence should be addressed to*

**The Employment Service Bureau, The Engineering Institute of Canada**

**2050 Mansfield Street, Montreal**

### Situations Vacant

MECHANICAL ENGINEER, about 30 years of age, with mechanical and combustion training. Will be used in technical or sales work. Apply to Box No. 1481-V.

MECHANICAL ENGINEER, under 30 years of age, to act as assistant to the Assistant Manager. The work comprises the design, construction and maintenance of general chemical plant and plant buildings. The position holds good prospects. Apply to Box No. 1489-V.

MECHANICAL DESIGNER DRAUGHTSMAN, familiar with pulp and paper mill equipment. Apply to Box No. 1490-V.

TECHNICAL ADVISER TO SALES department of manufacturing firm selling to pulp and paper mill industry. Must be familiar with mechanical design of pulp and paper mill equipment. Preferably one who has also had actual mill operation experience. Apply to Box No. 1491-V.

YOUNG ENGINEER, with electrical and civil experience or training to act as engineer for a small town in the province of Quebec. Apply to Box No. 1493-V.

ASSISTANT MASTER MECHANIC, for 10,000 E.H.P. plant in the province of Quebec. Young man required. Electrical and mechanical work. Good living conditions. Apply to Box No. 1494-V.

DRAUGHTSMAN, with at least ten years experience on general construction and machinery layouts, preferably in large mines. For the right man this position will have a degree of permanency. Apply to Box No. 1497-V.

### Situations Wanted

ELECTRICAL ENGINEER, B.Sc., E.E. Age 30. Completed C.G.E. Test Course; five years experience with power company utility work—substation and power house (steam) operation and maintenance, transmission and distribution line operation, maintenance and design. Industrial or utility work desired. Location immaterial. Available on short notice. Apply to Box No. 266-W.

MECHANICAL ENGINEER, B.Sc. Age 31. Married. Last ten years includes:—Mechanical structural and reinforced concrete design in pulp and paper mills, industrial plants, hydro-electric, mine, sewers and sewage disposal plant construction. My experience also includes shop production, steam plant combustion, fuel analysing, inspecting, supervising and instrument work on industrial construction. Permanent position preferred. Apply to Box No. 521-W.

DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aerophotographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.

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ELECTRICAL ENGINEER, B.Sc. '28; M. Eng. '35. Two years student apprenticeship at Can. Westinghouse Co., including test and electrical machine design. Also about two years experience in operating dept. of large electrical power organization. Available on short notice. Apply to Box No. 660-W.

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CIVIL ENGINEER, B.Sc. (Alta. '31), S.E.I.C. Experience includes three seasons in charge of survey party. Transitman on railway maintenance, and concrete bridge designing. Nature of work and location immaterial. Apply to Box No. 724-W.

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Why not register with the Employment Service Bureau of the Institute, or if you are already registered bring your record up-to-date?

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PLANT ENGINEER or SUPERINTENDENT, capable of supervising all phases of industrial plant operation, graduate electrical, eleven years diversified industrial experience including test course, four years on large Quebec industrial development, on construction and operation, also six years with prominent consulting firm supervising electrical and mechanical engineering projects. Age 31, single. Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman, compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

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CIVIL ENGINEER, B.Sc., O.P.E. Experience includes several years on municipal work-design and construction of sewers, steel and concrete bridges, watermains and pavements. Available at once. Apply to Box No. 950-W.

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CIVIL ENGINEER, B.A.Sc. (Toronto '33), S.E.I.C. Married. One year as instrumentman and draughtsman with provincial Highways Dept. One year on grading and reinforced concrete construction with Dept. of National Defence. One year in charge of contractor's branch office on highway paving job. Desire permanent position with opportunity for advancement. Apply to Box No. 1265-W.

ENGINEER AND DRAUGHTSMAN, Jr.E.I.C., age 33, married. Diplomas from Mtl. Tech. Inst. in R.C. and Structural Design. 11½ years experience in civil engineering, draughting and instrument work. This includes 7 years with M.L.H. & P. Cons. as field engineer on construction and maintenance of gas mains. Present location Montreal. Available at once. Apply to Box No. 1326-W.

CIVIL ENGINEER, M.E.I.C. Married. Age 38. Twenty years experience in organization, design and estimating, and cost accounting. Active service in France. Apply to Box No. 1367-W.

ENGINEER SUPERINTENDENT, A.M.E.I.C., R.P.E., Que. and Alta. Age 47. Married. Twenty years experience as engineer and superintendent in charge of hydro-electric, industrial, railroad, and irrigation construction. Specialized in rock excavation and suction dredging. Intimate knowledge of costs, estimating and organizing. Available immediately. Apply to Box No. 1411-W.

CIVIL AND ELECTRICAL ENGINEER, Univ. of Man. '35 and '36. S.E.I.C. Experience in irrigation and mapping. Available at once. Location immaterial. Box No. 1418-W.

CIVIL ENGINEER, B.Sc. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

SALES ENGINEER, M.E.I.C. Age 50. Married. Several years in combustion and general machinery lines. Estimating and layout work (mechanical and electrical). Speaking French fluently. Executive ability. Apply to Box No. 1482-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.Sc. '31 (Univ. of Alta.), Jr.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work, location immaterial and available at once. Apply to Box No. 1522-W.

CIVIL ENGINEER, B.Sc. '32, S.E.I.C., P.E.N.B., Dy.L.S.N.B., age 32. Experience in mining, both coal and metals, private and legal surveys, railroad construction, geology and building construction. At present in private practice in coal mining district. Desirous of changing location for position either in mining field or construction in Canada, or abroad. Apply to Box No. 1562-W.

# Recent Developments in Alaskan Aviation

**Extracts from a paper by Hugh Brewster, Supervising Aeronautical Inspector, Bureau of Air Commerce, Anchorage, Alaska, appearing in the January 15th, 1937, issue of the Air Commerce Bulletin.**

Alaska was not many years behind the States in the advent of commercial aviation following the war. However, the wild, rugged terrain, and the extremely variable climatic conditions of both the seasons and the various localities presented obstacles not easily overcome. Not until the late 1920's had the pioneers of Alaskan aviation sufficiently worked out the problems incident to flying in the Territory to demonstrate that it was to become the foremost means of travel if given the opportunity.

* * * *

In the early 1930's the industry "made haste slowly" building up volume of business painstakingly, lowering rates to the point where it was not only faster and more comfortable, but actually far cheaper for the large transient mining population of the interior mining camps to travel by airplane to railheads or seaports than to go "by hand" or by dog team. To sustain a profitable volume of business over the long winter months when mining operations were at a standstill, it was necessary to demonstrate to the permanent residents of the isolated villages that it was feasible for them to procure fresh eggs, meats, fruit and greenstuffs.

* * * *

Then came the momentous increase in the price of gold and with it a great new surge in mining activity throughout the Territory.

* * * *

Where it was necessary before for an airplane organization to base in a large railroad or seacoast town in order to obtain a profitable volume of business it now became possible for an individual operator to locate with one or two planes in any one of the key interior settlements and build up a nice little business "right in his own back yard." . . . At the present time there are twenty-one operators actively engaged in aviation in the Territory.

In the six months from January to June 1936, Alaskan aircraft operators flew 953,487 miles and carried 8,733 passengers. Statistics, by years, from 1930 to 1935 follow:—

Aircraft Operations in Alaska

| Year | Passengers Carried | Miles Flown |
|---|---|---|
| 1930 | 3,654 | 338,422 |
| 1931 | 5,292 | 454,312 |
| 1932 | 6,637 | 742,854 |
| 1933 | 6,237 | 1,019,891 |
| 1934 | 6,628 | 845,897 |
| 1935 | 16,441 | 1,931,736 |

The advent of the individual operator has opened a new field of aviation industry in the Territory. Since it is impossible for each operator of one or two planes to maintain complete shop facilities, demand has arisen for maintenance and repair agencies in the larger cities.

* * * *

The added number of planes and operators has given employment to a number of new pilots and mechanics in the territory.

* * * *

The labour turnover is necessarily very low, as the majority of the flying and mechanical work is of a far different nature than any experienced anywhere but in Alaska. It is safe to say that at least two years are required for either a pilot or a mechanic to become sufficiently acquainted with all of the unusual conditions encountered to make him an asset to his employer.

* * * *

Pilots must be able to service their own planes for long periods when away from their base.

* * * *

In winter it takes a pilot, working alone, never less than an hour to put a ship away for the night, and never less than two hours to get it ready to go in the morning. . . . More ingenuity, knowledge and persistence are required in flying float airplanes than in any of the other types of flying. This is principally true because an airplane on the water cannot be definitely controlled to the extent that it can on land on either wheels or skis.

* * * *

The pilot is solely responsible for his plane, many times is without aid from any source, and in localities without communication, where the loss of the plane would not be known without an expensive and time-taking search by other planes.

Aside from the ingenuity required of an Alaskan pilot in his principal work of flying, he must always be prepared to care not only for himself, but also for his passengers in the event of a forced landing. He must be a cook, hunter, trapper, and all-round woodsman. . . . Emergency rations carried are the result of years of experience and are surprisingly adequate for the weight represented.

A compilation showing the increase in number of pilots, aircraft and airports since 1930 follows:—

Pilots, Aircraft and Airports in Alaska

| Year | Licensed Pilots | | | | | Aircraft | | | Airports |
|---|---|---|---|---|---|---|---|---|---|
| | Transport | Industrial | Limited Commercial | Private | Total | Licensed | Identified | Total | |
| 1929* | 5 | 0 | 1 | 1 | 7 | 8 | 4 | 12 | 53 |
| 1930* | 5 | 0 | 4 | 6 | 15 | 14 | 5 | 19 | 66 |
| 1931* | 22 | 1 | 2 | 1 | 26 | 29 | 5 | 34 | 69 |
| 1932* | 28 | 1 | 2 | 16 | 47 | 28 | 8 | 36 | 75 |
| 1933* | 28 | 0 | 3 | 3 | 35 | 36 | 5 | 41 | 78 |
| 1934* | 37 | 0 | 4 | 4 | 45 | 29 | 1 | 30 | 76 |
| 1935* | 53 | 0 | 2 | 7 | 62 | 69 | 1 | 70 | 82 |
| 1936† | 56 | 0 | 3 | 10 | 69 | 74 | 2 | 67 | 83 |

*As of December 31.
†As of September 30.

Scheduled air-transport operation as it is known in the States is non-existent in the Territory. The small continuous volume of passenger travel caused by the seasonal nature of the work in the Territory and the lack of landing fields and weather reporting stations have prevented its development. The nearest approach to scheduled operation is carried on by the Pacific Alaska Airways of Fairbanks, division of the Pan American Airways system. Their operation consists of a weekly schedule from Juneau to Nome, with a side mail run during the winter weekly from Fairbanks down the Kuskokwim river to Bethel.

The Juneau-Fairbanks division is operated on wheels the year around, as the lack of snow in Juneau prevents the use of skis at that point. The snow on the Fairbanks field and on the intermediate fields is rolled to make it hard enough to support a wheel plane. Modern twin-engine ships are used on the main line, with single-engine transports operating on the Kuskokwim mail run. All ships are equipped with two-way radio and the company maintains a chain of ground stations situated at strategic points along each of its routes. Numerous landing fields have also been privately constructed. It remains for organizations of this type to determine whether scheduled operation is feasible in the territory and if not, to lead the way in making the already common charter service safer and more reliable by the addition of emergency fields, and weather reporting facilities.

Almost all of the government fields that have been built so far are situated at towns and settlements where there is a considerable volume of airplane traffic. This is also true of both government and private radio stations available for weather-reporting service. Practically all of the emergency landing fields and weather stations maintained along the principal air routes are maintained by the principal operators using such routes. . . . The effectiveness of the weather reports is lost to a great extent by the lack of information from intermediate points along the routes. . . . Alaskan aviation's prime present need is for weather stations and intermediate landing fields at such places. The inherent safety of ski and float operation has retarded this development to some extent, but it is only a matter of time until the big volume of flying will fall to the wheel planes. The larger mining districts are in localities inaccessible to float aircraft. Also, floats are expensive in both first cost and maintenance, and they detract from a plane's performance.

* * * *

This summarizes the difficulties that aviation in Alaska has surmounted to become a successful bidder for its place in the transportation system of the Territory.

## Cylinder-Bore Wear

To the Los Angeles Railway Corp., operating a fleet consisting of two hundred and thirty-three coaches, forty-five automobiles and fifty-nine trucks and tractors, the subject of cylinder-bore wear is one of considerable importance.

The first indication of wear in an engine is usually reported by the fuel clerk who notices a drop in the miles per gallon of fuel and miles per quart of oil, and if after the usual tests for leaking valves and so on, it appears necessary to take the engine down, the cylinders are calipered and, provided the wear does not exceed 0.010 to 0.012 inches new piston rings are installed. In the older types of engine this is usually necessary around 50,000 miles. After a total of from 0.015 to 0.020 inches has been reached, cylinders are reground and new piston rings fitted. This operation can usually be performed three times before it is necessary to discard the engine block, provided, of course, the walls have not been scored heavily or otherwise damaged. When this damage occurs, and the cost of a new block is considerably in excess of a repair job, sleeves are installed.

In the more modern engines a different picture is presented. Cylinders of engines inspected, which have operated from 200 to 300 miles per day over a period of one year, show little or no appreciable wear. A fleet of twenty engines equipped with the above type of engine has run an aggregate total of 2,500,000 miles without regrinding, although piston rings were replaced at approximately 57,000 miles on account of increased oil consumption.—*S.A.E. Journal.*

# THE ENGINEERING JOURNAL

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## CONTENTS



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# The Engineer and Non-Ferrous Alloys


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**Paper presented before the Montreal Branch of The Engineering Institute of Canada, February 25th, 1937.**



**SUMMARY.—The paper deals with such points in the metallurgy of non-ferrous alloys as concern the engineer, including composition diagrams, the characteristics of different phases of alloys, considerations governing the design of castings, the choice and standardization of alloys, and recent developments in the non-ferrous alloy field.**


Mechanical engineers are used to the outward performance in structural combinations rather than the inner life and activity of metals and alloys. In watching a tensile test to destruction, their main interest is in the force, as measured by the weight applied, that the specimen will withstand, rather than imagining the inner activities going on in the test bar causing some bars to have obvious and irregular plate-like formations after elongation, as compared with others that have a fine grained surface, both tests being on the same alloy.

Similarly in heat treatment the interest of the mechanical engineer is in the strength of the resulting product rather than the internal molecular changes that have occurred. If this be true, it may be of interest to view these and other phenomena through the eye of the metallurgist.

**Fig. 1—Wrought Iron, Magnification 100.**

First it must be noted that all metals and alloys are composed of an aggregate of crystals of varying form and shape held together by a non-crystalline or amorphous material which is another phase of the same metal or alloy. The terms alloy, solid solution, precipitation hardening, eutectic, intercrystalline shrinkage, crystal growth, dendrite, and also the use of the Greek letter descriptions such as Alpha Brass, Beta Brass, etc., were defined by the author in a paper in 1927,* but a number are now repeated.

*Bearing Metal Bronzes, by H. J. Roast, M.E.I.C., and Fred Newell, M.E.I.C., The Engineering Journal, April, 1927, p. 213.

**Fig. 2—P.M.G. Silicon Bronze.**

An "alloy" is a material having metallic properties and consisting of two or more elements, of which at least one is a metal.

By the term "solid solution" is meant the absorption, without changing the solid phase of the alloy, of two or more so-called compounds that exist as definite units capable of being seen under the microscope. They are then no longer visible in the microscopic field and are said to have gone into solid solution. A solid solution alloy has the characteristics of a pure metal.

"Precipitation hardening" is the increasing of certain physical properties by means of the following procedure. This procedure depends on the fact that certain alloys contain a constituent that by suitable heat treatment in the solid phase may be put into "solid solution" and may, by a further "precipitation heat treatment," be thrown out of solution in a finely dispersed sub-microscopic form. Or, as discussed by Merica in 1932, this hardening constituent may harden the alloy by distortion of the lattice structure without itself being precipitated.

"Eutectic" means the lowest melting point alloy of a given series; for example, the alloy of 63 per cent tin and 37 per cent lead (see Fig. 5), is the lowest melting point alloy of the tin-lead series. It is characteristic of eutectics that their melting point is lower than that of the lowest melting point constituent. They consist of two components frequently in a finely laminated form, though not always so.

"Intercrystalline shrinkage" is a separation of the bond between the crystals present in the inside of the metal due to the contraction of the same on cooling.

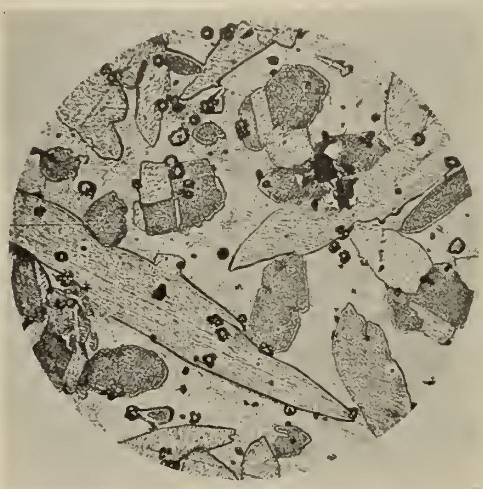


**Fig. 3—Manganese Bronze Casting, Magnification 100. Cooled in Sand.**

**Fig. 4—Manganese Bronze Casting, Magnification 100. Quenched from 1,000 degrees F. in water.**

"Crystal growth" is the simple increase of size of some crystals at the expense of others, such growth going on while the metal is in the solid phase.

A "dendrite" is a crystal formed during solidification having many branches and a tree-like pattern, the word comes from the Greek dendron—a tree.

The use of Greek letters to describe various compounds or phases is merely for the sake of nomenclature; numbers 1, 2, 3, etc., or the Roman alphabet A, B, C, would do equally well, except perhaps for the thought that the use of the Greek symbols gives a touch of erudition.

### Manganese Bronze

Consider as an example of the non-ferrous alloys a piece of manganese bronze, as it is generally called. Is this just a lump of metal? No, it is an aggregation of polyhedral crystals themselves of duplex structure. This duplex structure is capable of being enlarged or reduced, or resolved into one homogeneous mass of crystals by heat treatment. Accompanying these structural changes are increases or decreases in hardness, elasticity, tensile strength, yield points, etc. Therefore, this lump of metal is really very complex in nature. If this metal is heated to 1,500 degrees F., still a solid, quenched in cold water and again examined under the microscope, it will be found that all the duplex structure has gone into solid solution, or, rather, the Alpha Beta of the original has been changed by the Beta dissolving all the Alpha, leaving the whole of the metal in the Beta condition (see Figs. 6 and 7). If something is known of the physical constants of the Alpha and Beta, one may be guided as to what to expect in the way of physical changes due to the treatment. When it is known that strengths of from 55,000 to 110,000 pounds per square inch can be produced in manganese bronze, mainly by altering the ratio of copper to zinc in this alloy together with roughly 1 per cent of tin, aluminum, manganeze and iron, it will be realized that non-ferrous alloys have just as many complications as their ferrous cousins.

The best tool for studying the inside structure and activity of a piece of metal is the microscope. The procedure is as follows: A piece of the metal is obtained of about the same dimensions as a piece of cube sugar. One face is ground to a plane or flat surface by means of emery paper of increasing fineness. Finally it is polished and mounted so as to bring the plane surface at right angles to the vertical axis of the microscope. It should be mentioned that polishing differs essentially from grinding, no matter to what degree of fineness the latter may be carried. Polishing causes the metal, even the hardest, to flow, and an amorphous surface layer of extreme thinness is left by this operation. If the inside structure of the metal is to be viewed this amorphous layer must in general be removed. This is accomplished by etching the layer of metal with a suitable solvent. Certain structures, such as particles of slag, holes and unalloyed metal may be examined before the amorphous layer is removed, as these have resisted the flow effect and stand out in relief. In the case of the manganese bronze under discussion, a good etching medium is a 10 per cent solution of ammonium persulphate in water followed by an instantaneous dip in a weak solution of ferric chloride in hydrochloric acid, washing with cold water and drying rapidly.

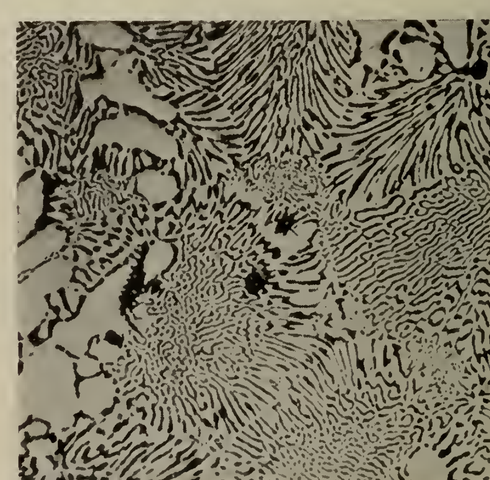


**Fig. 5—Eutectic Solder, Magnification 100. Tin 63 per cent. Lead 37 per cent.**

### Brass and Bronze Alloys

It might be well at this point to define the terms brass and bronze. Brass is an alloy of copper in which zinc is the dominating alloy element. Bronze is an alloy of copper in which zinc is not the dominating alloy element. It used to be stated that bronze was essentially an alloy of copper and tin but there are now bronzes that contain no tin at all.

As a further study consider briefly the constitution diagram of the copper-zinc series. The constitution diagram of any given series of alloys sums up the knowledge of the reactions of this series to alteration of ratio between the two components and of these ratios to varying temperatures. It is the result of the combined efforts of the foundryman, the metallurgist, the chemist, the physicist, the metallographist and the X-ray specialist. The data are obtained by:—

**Fig. 6—Manganese Bronze Casting, Magnification 100. Cooled in Sand.**

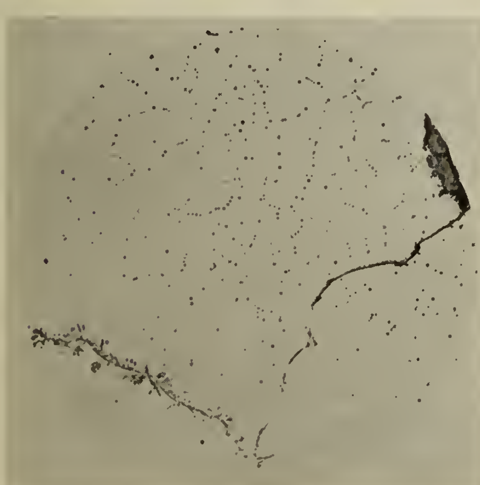


**Fig. 7—Manganese Bronze Casting, Magnification 100. Quenched in water from 1,000 degrees F.**

1. Melting a number of alloys of the two components from 0 to 100 per cent of each.
2. By making a thermal analysis of the various alloys, that is, recording the varying rates of cooling of the alloys and the peculiarities of the rate of cooling in each individual alloy.
3. By quenching samples at varying temperatures and examining them for their anatomical structure under the microscope.
4. By making X-ray examination of particles of these various alloys at the different stages.
5. By making chemical analyses of the various heats to check up the ratio of one component to the other and in rarer cases to ascertain the composition of compounds collected by means of centrifugal separation from the liquid phase.

Thus it will be seen that the final constitution diagram of this copper-zinc alloy series as in Fig. 8, or any other, is the result of collecting together the work of many investigators.

This constitution diagram shows that all the area above the curved line 1083, 905, 833, and 800 represents liquid metal, that is that any alloy of copper and zinc of given composition is entirely melted when raised to a temperature within this area. If any given spot be chosen on the diagram its physical condition as to liquid or solid, or both, is indicated, also its composition as to copper-zinc ratio and also as to its being in a state of solid solution or otherwise. Another important piece of information is the spread in temperature during which the metal is partly solid and partly liquid. This is indicated on the diagram by the liquidus-solidus area at any given point of composition. This will be referred to again later.

It is clear that any alloy of copper and zinc having under 33 per cent of zinc is in a state of Alpha solid solution at any temperature at which the alloy is solid. When 35 per cent of zinc is reached the alloy may be either a mixture of Alpha and Beta if quenched at any temperature higher than 1,300 degrees F.; or again entirely Alpha solid solution if below this temperature. It must be remembered, of course, that the constitution diagram is based on the alloy having time to reach its equilibrium at any given temperature. This is not always the case when an alloy is cast in sand, and never so if cast in a chill.

In general solid solution alloys are the most resistant to corrosion. This is especially so in the copper-zinc series. The 20 per cent zinc alloy is resistant to many corrosive liquids despite the corrodability of ordinary zinc in such liquid media. The well known Muntz metal is the 40 per cent zinc alloy of this series. This is not a solid solution but an Alpha Beta structure at any temperature below 1,410 degrees F. The area of the diagram made of Alpha and Beta Prime and Gamma is still under discussion and as Beta Prime is, if anything, a variety of Beta not distinguishable from Beta by microscopic examination, the matter need not be considered just now. An alloy of 45 per cent zinc will be practically a solid solution of Beta at any temperature at which it is in the solid phase. From 58 to 67 per cent zinc the alloy will be a solid solution of the Gamma phase.

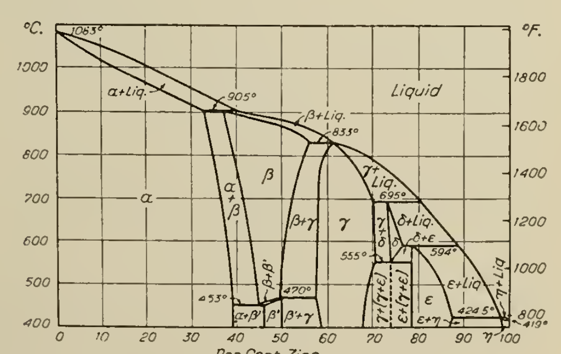



**Fig. 8—Constitution of Copper-Zinc Alloys.**

The engineer naturally asks what are the outstanding characteristics of these various constituents. Speaking for this series, the Alpha is a soft, comparatively weak constituent. The Beta is harder and stronger but less ductile. The Gamma is weak, hard and brittle. It is possible to so proportion the ratio of Alpha and Beta as to get within limits a required ductility with suitable strength and hardness.

Ordinary yellow brass is 30 per cent zinc and has the following physical constants as cast:—

Tensile strength....... 23,000 pounds per square inch

| | |
|---|---|
| Yield point | 7,000 pounds per square inch |
| Elongation | 35 per cent |
| Brinell hardness | 39 |

Muntz metal is 40 per cent zinc and has these constants:—

| | |
|---|---|
| Tensile strength | 40,000 pounds per square inch |
| Yield point | 14,000 pounds per square inch |
| Elongation | 40 per cent |
| Brinell hardness | 60 |

Brazing metal having 50 per cent of zinc must be carefully made as if the zinc be 52 per cent there is danger,

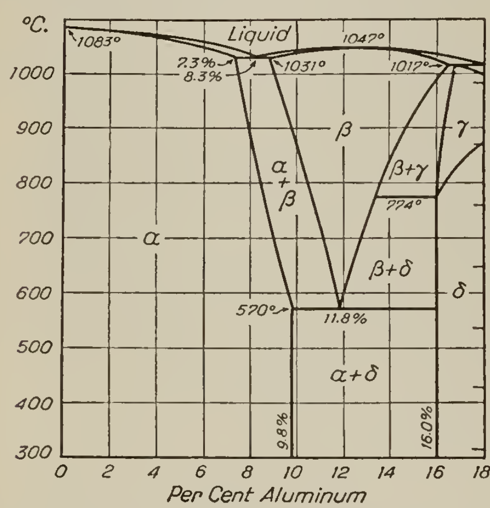



**Fig. 9—Copper-Aluminum Constitution Diagram. (Stockdale.)**

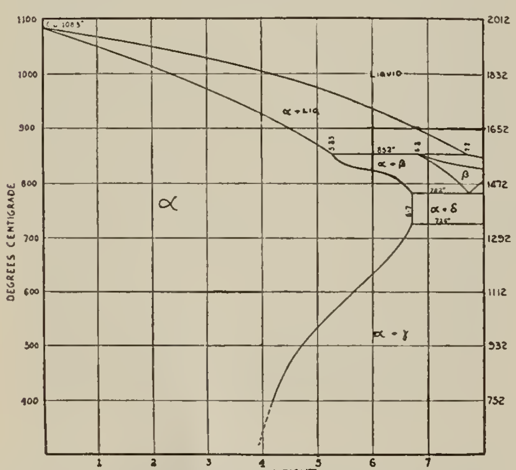



**Fig. 10—Copper-Silicon Constitution Diagram. (0-8% Silicon.) (Smith.)**

despite the chill effect of brazing, of getting some of the brittle Gamma constituent which greatly weakens the joint. The Gamma constituent of the copper-zinc alloys is not suited to mechanical uses, the same applies to the Delta, Epsilon and Eta modifications, until over 96 per cent of zinc content is reached.

The copper-zinc constitution diagram has been covered in some detail as it gives a good example of the complexities of non-ferrous alloys and the need of study of such aspects in the non-ferrous field.

### Solidifying Temperature Range

Certain alloys give trouble in the foundry and subsequently in the worked state due to segregation or solid solution concentration of the alloy components. The possibilities of this segregation or solid solution concentration are greatest with those alloys having the steepest temperature gradient in the solidus-liquidus area. If a comparison is made of the constitution diagrams of the series copper-aluminum, 9 per cent aluminum; copper-zinc, 10 per cent zinc; copper-zinc, 20 per cent zinc; copper-silicon, 4 per cent silicon; and copper-tin, 10 per cent tin, it will be seen that the solidus-liquidus temperature spread runs from practically nothing in the case of copper-aluminum to 54, 70, 130 and 270 degrees F. respectively for the remaining alloys (see Figs. 9, 8, 10 and 11). This means that the copper-aluminum alloy is in a class by itself as it passes directly from the liquid to the solid phase. This fact is a desirable quality from the point of view of the foundryman and the engineer and is a recommendation for the use of aluminum-bronze. At the same time aluminum-bronze has its own difficulties in connection with castings but as this is not a dissertation on a foundry subject, it is not necessary to go further into that matter at this time.

Of the remaining alloys the copper-zinc series lack the strength frequently needed, also corrosion resistance. The copper-tin alloy is the best known bronze but has the greatest temperature spread. The copper-silicon alloys have a reasonable temperature spread and have even greater strength than the tin-bronze and especially good anti-corrosion properties. It is this high temperature solidus-liquidus spread of the tin-bronzes that gives so much trouble in regard to segregation of high tin compounds and uneven crystals which carries with it varying solid solution concentrations, all of which tend to make for uneven corrosion attack.

### Choice of Alloy

The choice of a brass or bronze alloy for any given job is not always easy. Not only is strength a desirable feature but so is the property of being an easily cast alloy. After all a somewhat poorer alloy that can readily be cast by the ordinary jobbing foundry, at a comparatively low cost, may give a more reliable product than one requiring special moulding and melting experience that many foundries have not had occasion to acquire.

In making his decision it is well that the engineer should be acquainted with the outstanding features of

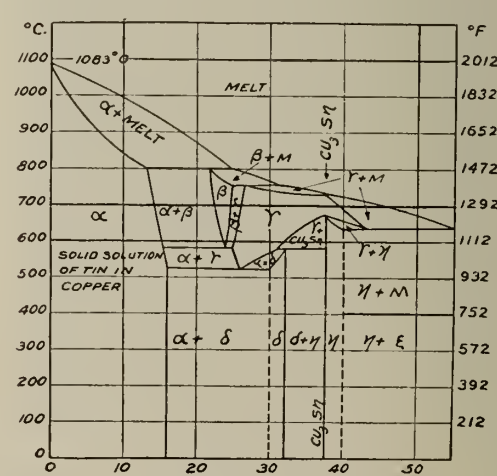



**Fig. 11—Copper-rich portion of the Copper-Tin Diagram.**

representative brasses and bronzes. High liquid to solid shrinkage generally goes hand in hand with great strength and shock resistance. The very shrinkage of the alloys results in the consolidation of the molecular and crystalline structure. The superior quality of steel over cast iron is in part due to the enormously greater shrinkage of the former. So it is that aluminum-bronze and manganese-bronze (or rather manganese-brass as it should be called) which have shrinkages nearly equal to steel, are the outstanding strong cast non-ferrous alloys. While manganese-brass, an alloy based on Muntz metal with certain 1 per cent additions, can have a tensile strength as cast of 110,000 pounds per square inch, aluminum-bronze has in addition to its strength of 70,000 pounds per square inch a greater fatigue resistance than manganese-brass. Unfortunately a high shrinkage constant gives a great deal of trouble in the foundry. Much greater care has to be taken to have as uniform a cross-section as possible, if not there is a strong tendency to develop surface and internal shrinkage at changes of cross-section, because the molten metal does not readily feed the heavier section on account of the fact that it is isolated by thin sections that solidify before the heavier ones. It is true, of course, that chills can be introduced and risers provided to offset these difficulties.

Another difficulty in the cases of aluminum and manganese-bronze is the readiness with which they form dross when they are agitated, the dross being composed of the oxide of the metal. If such dross remains in the casting it means weakness and porosity. Many mechanically ingenious methods have been worked out by the foundryman to offset this drawback. Naturally the special methods required increase the price of the castings from this type of alloy as compared with alloys less difficult to handle. The benefits of these super-strength brasses and bronzes are obvious and where the work is of sufficient importance to justify it they should, of course, be specified. Similarly special provisions have to be made in the production of castings of pure aluminum and to a less extent for the aluminum light alloys, while those of magnesium make still greater demands.

This is not a paper for foundrymen and the details of casting methods do not call for discussion. It is thought, however, that an understanding of the general founding characteristics of alloys is of benefit to the engineer.

On account of these difficulties of high shrinkage and drossing proclivities, alloys giving less trouble are to be preferred for ordinary purposes. The well known alloy copper 85, tin 5, lead 5, zinc 5 has comparatively small shrinkage and no drossing tendency, nor is segregation of the components a problem, the tin and zinc forming solid solution alloys with the copper, only the lead retaining its identity.

The alloy 88 copper, tin 10, zinc 2, is also free from drossing proclivity and undue mass shrinkage but it is sensitive in regard to intercrystalline shrinkage, particularly in the presence of traces of silicon or aluminum. By traces is meant percentages of the order of 0.005 per cent. Both these alloys are sensitive to chill effect, that is when cast into a sand mould in the form of a bar, say, 1¼ inch square and 6 inches long, the metal on fracturing will have a close fine texture for a depth of 1/16 inch to ⅛ inch, while the inner portion will be comparatively coarse. The more uniform and the finer the grain of a metal the better its properties as to pressure and corrosion resistance. It is for this reason that the recent silicon-bronzes such as P.M.G. have found favour.

These silicon-copper alloys have slight drossing characteristics but much less so than manganese or aluminum-bronze, their shrinkage is also less while their general constants are in between these and the tin-bronzes. The solidus-liquidus range at 4 per cent silicon is about 130 degrees F., about half that of a 10 per cent tin-bronze, and the alloy is in the solid solution group. Silicon-copper alloys have little if any chill effect when cast into sand, which means that the close grain structure extends throughout a heavy cross-section even up to 3 inches, which in its turn explains to some extent at least their pressure and corrosion resistance properties.

### Forgeability

Forgeability is often a desirable attribute. Brasses containing less than 35 per cent of zinc are not readily forgeable. This is borne out by the fact that castings of these metals are commonly heated to a red heat and broken up by a sledge hammer. Manganese-bronze, aluminum-bronze and silicon-bronze may be readily forged at a bright red heat and tin-bronze also but to a less extent and between narrower temperature limits (further reference to these bronzes is made under section "Heat Treatment"). In fact in the case of aluminum-bronze a gate of, say, ½ inch cross-section attached to a casting may be twisted a complete turn and back again while at a bright red heat without detaching it from the casting. Muntz metal, the copper-zinc alloy of 40 per cent zinc, forges well at a red heat due to the Beta associated with the Alpha, while in the cases of aluminum-bronze and silicon-bronze the Alpha is itself forgeable.

### Precipitation Hardening and Heat Treatment

In the field of the aluminum and magnesium light alloys considerable advance has been made in precipitation hardening and heat treatment. As already stated the mechanics of precipitation hardening is that there is a constituent in the alloy (generally in small proportions) that can be put into solid solution at one temperature and reprecipitated in a fine state of division at another temperature. Frequently the reprecipitation takes place slowly at room temperatures but can be made to complete itself in a few hours under the correct heat treatment temperature. At its best the precipitated substance is too fine to be seen microscopically but its effect is shown in the improvement of the physical properties. The new copper-beryllium alloys give an outstanding example of precipitation hardening. The constitution diagram (see Fig. 12) indicates that there is a solid solution area of Alpha possible up to 2.4 per cent beryllium, that there is an Alpha Beta and Beta area and an Alpha and Gamma area.

In this alloy Alpha is ductile, Alpha Beta hard and brittle and Alpha Gamma hard and not brittle. With this to work on it is found that if an alloy of 2.15 per cent beryllium be cast and quenched at a temperature within the Alpha area, say 1,472 degrees F., it can be retained in the soft Alpha condition. If this metal be then reheated to

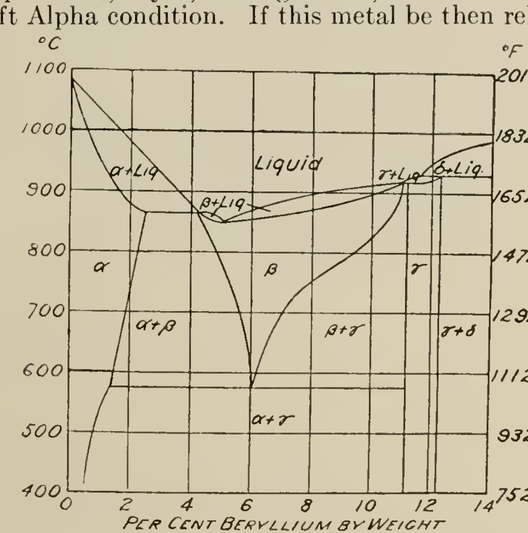



**Fig. 12—Copper-Beryllium Constitution Diagram.**

572 degrees F. for two hours the Gamma phase will be precipitated in a very fine state of division with the following astonishing results:

| | Quenched from 1,472 degrees F. | Quenched from 1,472 degrees F. and reheated to 572 degrees F. |
|---|---|---|
| Tensile strength.................. | 70,000 | 175,000 p.s.i. |
| Yield point....................... | 31,000 | 134,000 p.s.i. |
| Elongation........................ | 45 per cent | 6.3 per cent |
| Brinell hardness.................. | 110 | 340 |

### Heat Treatment

In the case of aluminum and manganese-bronze heat treatment is used to hold the alloy in the required condition, Beta or Alpha form (at other times the Alpha Beta mixtures are obtained by altering the composition). Copper-tin bronzes afford an opportunity of heat treatment and, in fact, the Chinese thousands of years ago were well aware of this possibility, although probably not knowing the underlying scientific reason. For example, when they wanted to

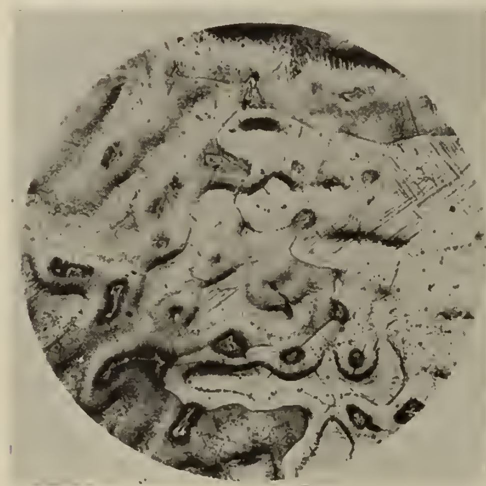


**Fig. 13—10 per cent Tin-Bronze, Magnification 100, as Sand Cast. (Note Dendritic structure and tin-copper compound.)**

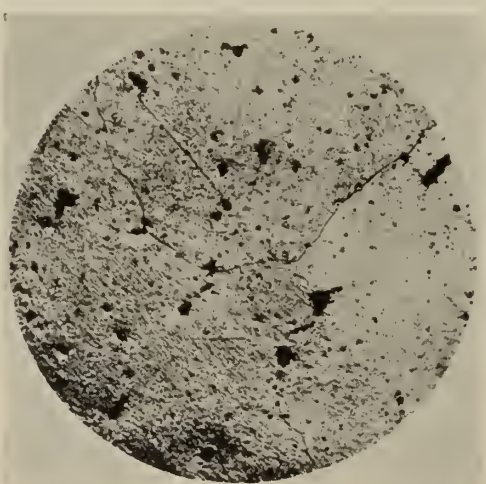


**Fig. 14—10 per cent Tin-Bronze, Magnification 100, as Annealed at 1,000 degrees F. (Note that Dendritic structure and tin-copper compound have gone into solid solution.)**

hammer out bronze gongs they heated the bronze to a dull red heat because they found that until this temperature was reached the bronze was brittle. They also found that if they heated it to a bright red heat it again became brittle, with the result that they forged or hammered out their gongs within this temperature range.

Assuming that the bronze was of a composition 17 to 20 per cent tin, then the explanation is as follows: The Alpha constituent is soft and ductile, the Beta constituent is stronger and less ductile, the Gamma and Delta constituents are hard and brittle. A mixture of Alpha and Beta is forgeable at the right temperature. A mixture of Alpha and Delta is not forgeable. In addition the change from Alpha and Delta at room temperatures to Alpha and Beta occurs at about 1,000 degrees F. (a just visible red heat) and is complete at 1,472 degrees F. (a bright red heat) above which part of the interior of the alloy is liquid, which is a scientific explanation of the Chinese modus operandi. (See Fig. 11.) The forgeability of Alpha Beta depends on the fact that both constituents are forgeable, whereas in the case of Alpha Gamma, although the Alpha condition is forgeable, the Gamma is not. In the case of the low tin-bronzes, the Alpha condition can itself be forged.

The characteristic dendritic structure of 10 per cent tin alloys can be removed by annealing at 1,000 degrees F. (see Figs. 13 and 14).

### Importance of Homogeneity

The importance of homogeneity in brass and bronze as to density and crystal size is a point often overlooked by the engineer and as a result pressure and corrosion characteristics are not what they should be. Not only should the engineer want good metal to go into the casting but also that the casting be of a nearly equal strength as the absolutely necessary changes in the cross-section will permit. If the casting is to be subsequently machined and then used for pressure work or corrosion resistance the uniformity of the crystals and also the actual size of the same become of major importance.

Take a bushing of, say, ¾-inch wall as cast, with a heavy collar near one end of, say, 1½-inch cross-section. The sand cast bushing in, say, 88 copper, 10 tin, 2 zinc will have a narrow width of chill, in which area the crystals are small and of uniform size, the centre portion of the metal having larger crystals. In the inside of the heavy cross-section these crystals will reach their maximum and unless special provision has been made they will be very dendritic. The cohesion of large dendritic crystals is likely to be weak and moreover microscopic channels may exist and finally reaching the surface, the casting leaks. Safety lies in providing ample feeding of hot metal to such a heavy cross-section of the casting so that even if the crystals are large they will be dense and well knit together. Such a casting will not leak under hydrostatic pressure. Another protection is to chill the metal at this point.

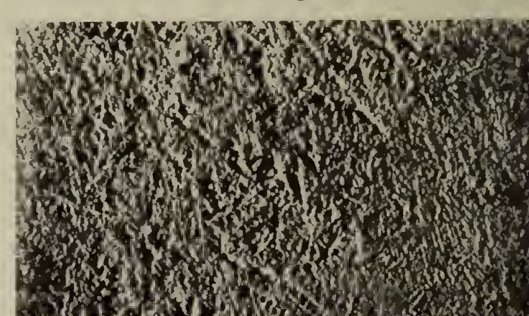


**Fig. 15—Three-inch Diameter Bronze Stick Composition. 85 per cent copper—5 tin—5 lead—5 zinc. Unevenly Fed.**

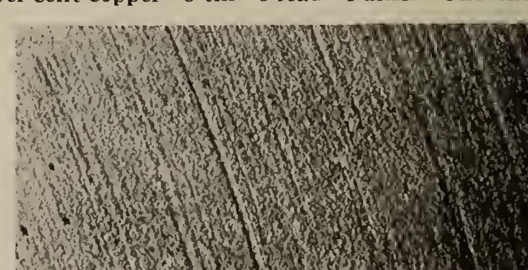
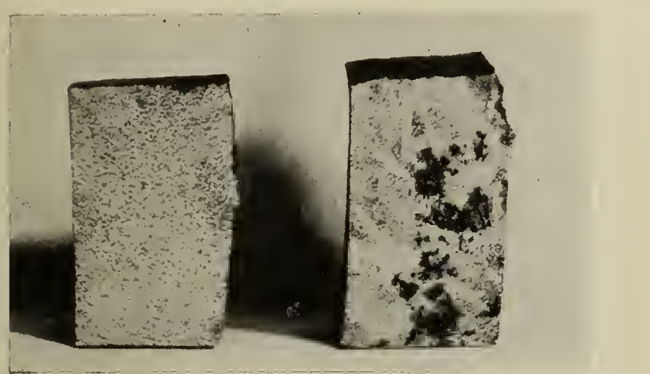


**Fig. 16—As Fig. 15. Evenly Fed. (Scratches are saw marks.)**

If the problem is one of corrosion resistance it is not enough to have the crystals well knit but they must also be of the smallest size that is compatible with maximum cohesion. Stick bronze of composition 85 copper, 5 tin, 5 lead, 5 zinc, gives a good example of homogeneity. In general stick bronze is not homogeneous as to crystal size and for this reason does not resist corrosive attack uniformly. This can be shown by sawing a 3 inch stick of brass in two, grinding one half to a flat surface and "deep etching it." By deep etching is meant putting the casting into a dish containing a solution of three parts of nitric acid, one of hydrochloric and one of water, all acids being commercial, and leaving it there for ten minutes. It is then removed and plunged immediately into cold water, finally washed under the tap, dried and painted with clear white shellac. After such a treatment the stick brass will have a



A B

**Fig. 17—P.M.G. Bronze. A—properly made, B—coarse crystals.**

surface that shows that it is not uniformly attacked. The chilled outside edge will be found to have eaten away uniformly but fissures will be seen between the crystals in the inside area. (See Figs. 15 and 16.)

If the metal be allowed to enter the mould in a manner to permit it to feed itself uniformly and the same test be applied, it will be found to be attacked equally over the whole area by the etching solution, there being no crevices opened up between the crystals. Apart from the composition or nature of the alloy it will be found that this fineness of grain and maximum provision for shrinkage must be provided if the best results are to be forthcoming. Another example is that shown in Fig. 17 of P.M.G. alloy, one with small uniform crystals and the other with un-uniform crystals.

### Relation of Design, Pattern and Final Casting

The engineer generally wants strength primarily, that is strength in the whole of any given casting. It is reasonable to assume that the useful strength is that point at which the relation between the actual strength of the casting and the maximum force it has to withstand bear the lowest ratio to each other. There may be parts in the casting that are actually weaker than such a point but which under the conditions have less strain put upon them. In order that the engineer may attain his objective he must consider in his design the characteristics of the metal to be used and the practicability of producing a satisfactory casting in the foundry. This entails either a knowledge of such matters or consultation with those who have such knowledge. In the matter of shrinkage, this characteristic of the alloy does not mean the shrinkage indicated on the patternmaker's rule, but the performance of the alloy where a heavy cross-section joins a light. Other considerations such as the need of elimination from the casting of sharp angles and undercut projections, and the limitations of the founding art concerning small diameter cores of considerable length, etc., etc., must receive attention if trouble is to be avoided. The more consultations between the designing engineer, the patternmaker and the foundrymen, the better. It is not uncommon for the patternmaker to be instructed to keep the machining allowance low in order to reduce the weight of the casting and therefore the intrinsic value thereof. In such manner is the door opened to false economy. It is true that the foundry replaces free of charge, that is free of direct charge, a faulty casting, but the engineer is put to the expense and loss of time that the machining has required. A more generous machining allowance is in the end an economy of both time and money. A custom that has nothing to recommend it is that of producing a pattern of improper foundry design and as the first foundry to which it is sent turns out a bad job, shopping around from foundry to foundry until some unlucky wight succeeds, more by good luck than good management, in obtaining one satisfactory casting. This immediately strengthens the purchasing agent's hand and he says to all the other foundries—"We got a good casting from A, therefore the pattern is all right." The fact of the matter is the pattern design was fundamentally wrong and although under a fortuitous combination of circumstances one good casting was obtained, it is no argument that the pattern was right. Had the pattern been right all reasonably good foundries would have been able to handle it.

Suppose that the casting has been properly designed, properly "patterned" and cast, it may still be spoiled by poor machining, either due to sharp angles or rough finish. Engineers of all people should appreciate the result of these errors in connection with their stress concentration effect, a frequent cause of subsequent progressive fracture. Much has been said and doubtless much has been learned in this connection but every day brings examples of the continuation of these fundamental mistakes.

### Test Bars

No discussion of this nature should omit the vexed question of test bars. The requirement often made is that the test bar form an integral part of the casting. The reason for this is that it was intended to protect the purchaser from the reprehensible custom of submitting as representative of the given casting a test bar from another melt altogether. However test bars have been welded onto steel castings after they were cast but before the inspector arrived. The answer to this sort of malpractice is to confine one's dealings to firms of recognized and established probity. There is, of course, a reason for the statement that it is unsatisfactory to insist on the test bar being integral with the casting, and the answer is found when it is agreed as to what is the purpose of the test bar. It is neither to indicate the strength of the casting at all points nor to inform one of the strength of the casting at any

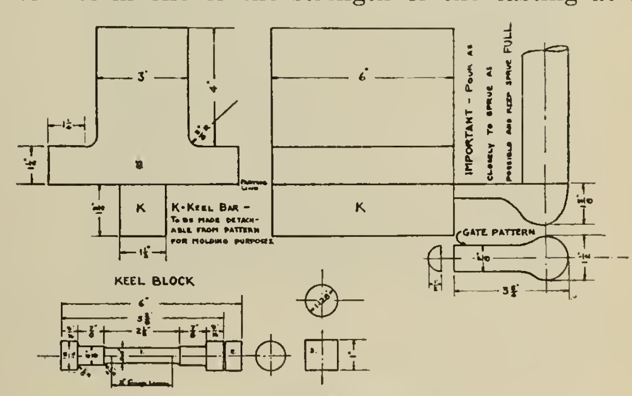



**Fig. 18—Standard Keel Block.**

particular point nor to show the elasticity or rigidity of the casting; the function is simply to show the quality of the metal used to make the casting—nothing more. This can only be done if the test bar is cast at the optimum temperature for the pattern from which it is made, the pattern itself being such as to bring out the reasonable constants of that particular metal. The nearer the cross-section of the test bar is to the average cross-section of the casting, the better. For example, it is fairer and better for all concerned to cast a reasonably heavy bar rather than a small cast to size bar. When the test bar is machined out of the larger bar the element of skin strength is eliminated and although some of the constants obtained may be lowered, they give a good average as compared with the small bar and its higher constants due to skin or chill effect.

One of the most important considerations is the complete feeding of the test bar.

Let us look at the keel block form of test bar, described, though not originated, some years ago in the Roast-Newell

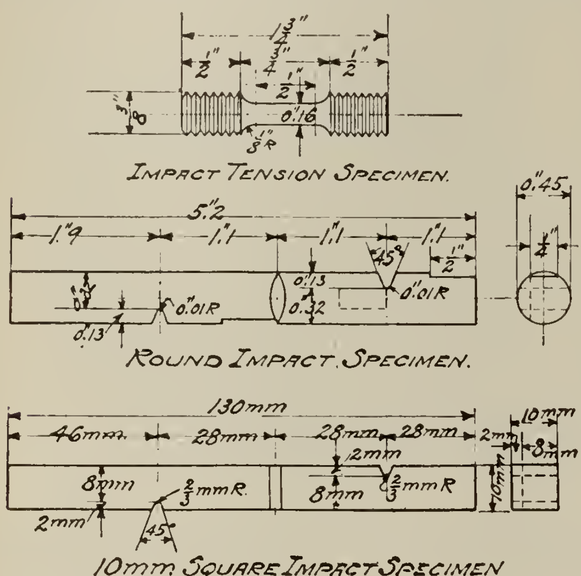


Fig. 19

paper to which reference has already been made. This pattern ensures perfect feeding, gives a fairly heavy cross-section from which to machine the bar, has a reasonably slow cooling rate (made as it is in a dry sand mould), gives three bars of closely agreeing physical constants and will, in the hands of different operators, give closely agreeing results (see Fig. 18). If desired, one side bar can be used for tensile test, the other for Izod test, as per Fig. 19, and the keel bar for compression specimen and Brinell. The shock or impact test as also indicated in Fig. 19 will be found useful.

If the test bar be attached to the casting it may draw metal from the casting and thus weaken it or may be drawn upon by the casting, thus weakening the test bar. Further, the temperature of the metal at the time of its entry into the test bar may not be the optimum temperature required. When it is borne in mind how sensitive is the question of feeding molten metal as it passes from the liquid to the solid state, then one can appreciate the differences in physical constants between one part of a casting and another. This is a problem of design and foundry practice and is a thing apart from the quality of the metal. If, however, the metal poured is not of good quality, then the whole of the casting will be inferior. This question of quality of metal is what the test bar controls.

If the importance of the casting justifies it, the casting may be cut up or fractured, the fracture examined and test bars taken from areas of different cross-section. After this the engineer and foundryman in consultation will be able to modify the design and pattern to correct any weaknesses that have been discovered.

### Specifications

Nine-tenths of the non-ferrous alloy specifications should be eliminated. Practical scientific bodies, such as The Canadian Engineering Standards Association, The American Society for Testing Materials, The American Foundrymen's Association, The American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers and the British Standards Institution have stamped with their considered approval enough non-ferrous alloys to cover all but the most unusual requirements. Why then are over 8,000 alloys listed in so recent a book as "Engineering Alloys"?* Largely because individual consulting engineers, plant engineers and supply engineers have from time to time found a certain piece of metal to give long and satisfactory service. This they proceed to have analyzed (as though composition were the main criterion of longevity) and the result of this analysis is recorded and becomes alloy 8001. The more scientific way is to study existing standard alloys and see which one is most suited. It is a pity that so little information is to be had regarding the proved uses for alloys and this is a field that needs considerable extension.

In any case some alloy has to be specified and composition is the easiest starting point. Certain metals and metalloids shall and others shall not be present. There are admitted limitations to chemical analysis, all percentages therefore should be expressed as maximum and minimum and desired figures, and in the case of small amounts of impurities a note as to how much should be taken for analysis, the absence of which impurity under these conditions should constitute "none."

The question as to whether virgin metal or other is to be used will be covered in part by the price the engineer purchaser wishes to pay. It is no use specifying virgin metal and then shopping around until the lowest price submitted is less than the cost of the component virgin metals, to say nothing of manufacturing cost and profit. It has been abundantly proved that in many instances good scrap metal is at least equal to virgin, particularly if to the usual additions there be added a modicum of metallurgical brains. The most direct check on metal quality is the test bar under the conditions already described. It is legitimate and desirable to add that the casting shall be clean and free from shrinkage, either inside or out. It is unfair to insist on anything in a specification that is not actually checked by the purchaser. Neglect to do so reacts unfairly on those who charge a fair but higher price for fulfilling all the requirements stated as compared with those whose price is lower because they do not intend to fulfil all the conditions.

It would be a great help to the foundry if purchasing agents wanting a special alloy would state the name of the specification as well as the designating letter or number. If these designations were prefixed by such letters as S.A.E. and C.E.S.A., etc., the information could readily be obtained.

### Wear

The question of wear is of interest to engineers and there are many anomalies in this connection. For instance the hardened steel razor blade is sharpened on a soft leather strap, the hardness of the rubber eraser on your desk is shown by the scleroscope to be greater than the hardest steel, augers are sharpened on a soft lead banded wheel. Similarly the softer, less dense bronze will outwear a harder, denser bronze under such conditions as bearings for locomotives.

In a series of tests recently made on bronze, two pieces of identical size and shape were put in a suitable machine, ample lubrication provided and the specimens pressed against a revolving steel axle. The two sets were made of the same chemical composition, actually out of the same melt, the one cast so as to be dense metal, the other to be more porous metal. After cleaning the specimens the weight was taken at each one million revolutions. The softer, weaker, and less dense bronze showed the least wear. This led to an investigation as to the oil absorbing properties of the two classes.

It was found quite feasible to get constant results, by washing the specimens, weighing about an ounce, in ether,

*Published by the American Society for Metals.

placing them in a desiccator, drying them, and after allowing them to reach the same temperature as the balance room, weighing them to within one tenth of a milligramme. They were then warmed to 200 degrees F., and put into the lubricant used for the test. After an interval they were removed, wiped and weighed till the weight remained constant. The increase in weight was taken as representing the oil absorbed. The better wearing bronze showed a definite increase over the other in the amount of oil absorbed.

### Aluminum and Magnesium Alloys

Aluminum and magnesium base alloys include outstanding examples of the rapidity with which scientific discoveries are turned into commercial accomplishment and not by hit and miss rule of thumb methods but by definite logical scientific reasoning. Duralumin, with the general composition copper 4 per cent, magnesium 0.5 per cent, manganese 0.5 per cent, balance aluminum, is a good example. Starting with aluminum, a metal of high shrinkage constant, difficult to cast, low in strength, incapable as all really pure metals are of improvement by heat treatment, the addition of such metals as copper and silicon suggested themselves. While this gave higher tensile factors, the strength and the hardness were still low. Attention was turned to the possibilities of precipitation hardening, so thoroughly investigated by Merica, it having been found that the copper-aluminum compound $CuAl_2$ could be put into solid solution by heating to 932 degrees F. and quenching in water. The alloy would then age-harden at room temperature until the strength was double.

As magnesium is only some two-thirds the weight of aluminum, and as the demand was growing for still lighter fabricating alloys, the magnesium base alloys have developed along the same general lines, till today there is the Dow Company's alloy of magnesium having, after heat treatment, a tensile strength of 39,000 pounds per square inch.

In England a company has developed an aluminum-magnesium-cerium alloy for use in aeroplane parts. This alloy indicates the complicated nature of some of these light alloys. It contains copper, nickel, magnesium, silicon, iron, cerium about 1 per cent, balance aluminum. It is capable of heat treatment based on precipitation hardening and before heat treatment the chill cast material has a Brinell hardness of 67 to 77. After heat treatment the Brinell hardness is between 130 to 140. At the same time the yield point and tensile strength are increased.

### Co-operation of Engineers

Two influences have been at work all these years. The steady logical research of trained metallurgists and physicists, undertaken purely as research, and the demands of the engineer for ever stronger and lighter alloys to meet the new call for heavier than air transportation and lightweight trains. The co-operation of both has been necessary to bring the light alloys to their present development.

### Tin-Lead Alloys

Another division of non-ferrous alloys is that of white metals exclusive of aluminum and magnesium, namely tin, antimony and lead. In general the uses of solder and babbitt are well known, but even here much progress has been made since definite scientific methods have been invoked. This is especially true concerning the ill-effects of the presence of such metals and elements as copper, zinc, antimony, lead, silicon and occluded gases. Also of the importance of the condition of the surface of metal before tinning or babbitting, the definite effect of rate of pouring, temperature of metal and temperature of mould, etc.

Considering impurities first, the presence of zinc is apparent by the surface of the molten metal or the appearance of the exposed surface of the cast metal. Its effect is to make the alloy sluggish and difficult to pour, and to interfere with the proper adhesion of the two metal surfaces. The presence of copper causes the metal to act in a similar manner, a compound with antimony, $Cu_2Sb$, is very brittle and this has to be borne in mind. The unique violet colour of this copper antimony compound is a help in its detection (see Fig. 20).

In the presence of a sufficient quantity of tin the preference of copper for tin eliminates the possibility of the $Cu_2Sb$ existing under ordinary conditions and the preference of antimony for tin over its preference for lead gives rise to the compound SnSb.

In babbitting engineers are primarily interested in the adhesion of the babbitt to the bearing whether it be steel

**Fig. 20—Copper Antimony Eutectic, Magnification 100. Dark bars are violet $Cu_2Sb$ and dark background is also $Cu_2Sb$.**

**Fig. 21—Babbitt, Magnification 100. Composition. Tin 83⅓ per cent; Antimony, 8⅓ per cent; Copper, 8⅓ per cent; The squares are SnSb; the Stars are Tin-Copper compound.**

or bronze. It may be of interest to outline briefly the pitfalls in this connection. To take a bronze bearing as an example, tin is the best medium to use as a bond between the bronze and the babbitt. To list the pitfalls categorically:—

1. No proper adhesion is possible between tin and a cast metal surface due to the film of oxidized metal on the latter.

2. No mechanical bond, such as is attempted by the insertion of undercut V slots, is as good as the bond provided by the interpenetration of tin into the clean surface of metal and of the babbitt into the tin.

These figures are all the average results of actual tests on commercial quantities by Harold J. Roast M.E.I.C. and Lecturer in Metallurgy McGill University - May 1935

| | DESCRIPTION | COMPOSITION: Copper | P.M.G Hardener | Zinc | Tin | Lead | Iron | Alum'm | Manganese | Nickel | Phosphorus | Silicon | Magnesium | TENSION: Yield Point | Ult. Ten. Str. | Elong'n on 2" | Inside Brinell Hardness | Izod Impact Ft lbs | COMPRESSON: Def. Limit | Reduction at 50000 | Reduction at 100000 | Casting Temp. °F for Test Bars | — USES — | Wt per Cu. ft in lbs. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | P.M.G. Cold Drawn 92-8 | 92 | 8 | - | - | - | - | - | - | - | - | - | - | 65.000 | 90.000 | 20 | 175 | 20 | - | - | - | - | Duplicates Steel Shafting | - | 1 |
| 2 | P.M.G. 80-20 | 80 | 20 | - | - | - | - | - | - | - | - | - | - | 50.000 | 50000 | 0 | 190 | 2 | 35.000 | 0.0014 | 0.068 | 1900 | Turntables for Bridges | - | 2 |
| 3 | " 85-15 | 85 | 15 | - | - | - | - | - | - | - | - | - | - | 33.000 | 40.000 | 3 | 120 | 5 | 22 000 | - | 0.168 | 1900 | Non Sparking Hammers. | - | 3 |
| 4 | " 87-13 | 87 | 13 | - | - | - | - | - | - | - | - | - | - | 23.000 | 50.000 | 12 | 116 | 9 | 21.000 | 0.055 | 0.193 | 1900 | ditto | - | 4 |
| 5 | " 88-10-2 | 88 | 10 | 2 | - | - | - | - | - | - | - | - | - | 24.000 | 52 000 | 25 | 95 | 16 | 14000 | 0.056 | 0.176 | 1900 | For some purpose as Gun metal | 528 | 5 |
| 6 | " 88-10-2 @ 932°F | 88 | 10 | 2 | - | - | - | - | - | - | - | - | - | - | 21.280 | - | - | - | - | - | - | 1900 | and for superheated steam. | 528 | 6 |
| 7 | " 90-10 | 90 | 10 | - | - | - | - | - | - | - | - | - | - | 20.000 | 54000 | 30 | 96 | 20 | 15.000 | - | 0.180 | 1900 | Acid resisting and bearings | 528 | 7 |
| 8 | " 92-4-4 | 92 | 4 | 4 | - | - | - | - | - | - | - | - | - | 18.000 | 40.000 | 60 | 57 | 60+ | 14.000 | 0.126 | 0.288 | 1950 | Extreme toughness | - | 8 |
| 9 | " Brass | 58 | 3 | 39 | - | - | - | - | - | - | - | - | - | 46.000 | 80.000 | 16 | 146 | 14 | 26.000 | 0.009 | 0.095 | 1850 | as for Manganese Bronze | 520 | 9 |
| 10 | Tin Bronze 80-20 | 80 | - | - | 20 | - | - | - | - | - | - | - | - | 28.000 | 30.000 | 0.5 | 135 | 3 | 24.000 | - | [illegible] | 1900 | Turntables for Bridges | 530 | 10 |
| 11 | " 84-16 | 84 | - | - | 16 | - | - | - | - | - | - | - | - | 26.000 | 30.000 | 1 | 85 | 1 | 20.000 | - | [illegible] | 1900 | ditto | 536 | 11 |
| 12 | " 88-10-2 | 88 | - | 2 | 10 | - | - | - | - | - | - | - | - | 20.000 | 35.000 | 20 | 65 | 15 | 14.000 | - | 0.27 | 1900 | General purpose high quality Tin Bronze | 551 | 12 |
| 13 | " 88-10-2 @ 932°F | 88 | - | 2 | 10 | - | - | - | - | - | - | - | - | - | 12.320 | - | - | - | - | - | - | 1900 | | 551 | 13 |
| 14 | " 90-10 | 90 | - | - | 10 | - | - | - | - | - | - | - | - | 18.000 | 35.000 | 15 | 70 | 8 | 13.000 | - | 0.26 | 1900 | Acid resisting | 556 | 14 |
| 15 | Leaded Bronze High Tin | 80 | - | - | 10 | 10 | - | - | - | - | 0.024 | - | - | 16.000 | 25.000 | 15 | 55 | 4 | 15000 | 0.165 | 0.30 | 1900 | Bearings | 556 | 15 |
| 16 | " " " " Lead | 70 | - | - | 10 | 20 | - | - | - | - | - | - | - | 16.000 | 30.000 | 17 | 65 | 5 | 11.000 | 0.131 | - | 1900 | Bearings | 592 | 16 |
| 17 | Leaded Bronze Engine | 76 | - | 2 | 7 | 15 | - | - | - | - | - | - | - | 14 000 | 24.000 | 15 | 55 | 7 | 12 000 | - | 0.330 | 1900 | ditto Can Rys Engine bearings | 586 | 17 |
| 18 | " " Journal | 72 | - | 3 | 5 | 20 | - | - | - | - | - | - | - | 12.000 | 20.000 | 12 | 50 | 7 | - | - | - | 1900 | ditto " " Car " | 590 | 18 |
| 19 | " " Nickel | 76 | - | 1.75 | 7 | 14.5 | - | - | - | 0.75 | - | - | - | 16000 | 25.000 | 18 | 55 | 6 | 13 000 | - | 0.417 | 1900 | ditto " " Engine bearings | 584 | 19 |
| 20 | Diamond Hytensil | 85.5 | - | 4.5 | 8 | 2 | - | - | - | - | - | - | - | 16.500 | 30.000 | 20 | 60 | 10 | 12.000 | - | 0.30 | 1900 | Valves and Fittings | 536 | 20 |
| 21 | " Utility | 76 | - | 2.0 | 7 | 15 | - | - | - | - | - | - | - | 14.000 | 24.000 | 15 | 55 | 7 | 12.000 | - | 0.330 | 1900 | General purpose Bronze Bearings | 586 | 21 |
| 22 | " Bull Dog | 76 | - | 1.75 | 7 | 14.5 | - | - | - | 0.75 | - | - | - | 16.000 | 25.000 | 18 | 55 | 6 | 13.000 | - | 0.417 | 1900 | Bearings Heavy Duty | 584 | 22 |
| 23 | " Hyphos (CPRIF) | 92.5 | - | - | 7 | - | - | - | - | - | 0.50 | - | - | 18.000 | 30.000 | 15 | 60 | 9 | 11.000 | - | - | 1900 | Superior Quality Steam Gears, Worm Wheels | 542 | 23 |
| 24 | " Acid | 76 | - | 2.0 | 7 | 15 | - | - | - | - | - | - | - | 14.000 | 24.000 | 15 | 55 | 7 | 12.000 | - | 0.330 | 1900 | Acid resisting | 586 | 24 |
| 25 | " Hyhete | 63.7 | - | 7.0 | - | - | 0.50 | 8.0 | 0.40 | 20.0 | - | 0.40 | - | 30.000 | 80.000 | 2 | 200 | 2.5 | - | - | - | 2100 | Heat Glass Machine Dies etc. | - | 25 |
| 26 | " Manganese | 57 | - | 39 | 1 | 0.5 | 1 | 1 | 1 | - | - | - | - | 30.000 | 60.000 | 20 | 110 | 20 | 25.000 | 0.04 | 0.15 | 1850 | Good for strength but not for steam | 524 | 26 |
| 27 | " Aluminium Alloy #43 | - | - | - | - | - | - | 95.0 | - | - | - | 5.0 | - | 8.000 | 18.000 | 3 | 40 | - | - | - | - | 1200°F | Leak proof casting Pressure | 168 | 27 |
| 28 | " " " #113 | 7.5 | - | 1.5 | - | - | 1.2 | Bal | - | - | - | - | - | 13.000 | 20.000 | 2 | 50 | - | - | - | - | 1200°F | General purpose | 178 | 28 |
| 29 | As Cast " Y Alloy | 4.0 | - | - | - | - | - | Bal | - | 2 | - | - | 1.5 | 24.000 | 28.000 | 1 | - | - | - | - | - | 1200°F | Pistons Deisel and other Heat treated | 173 | 29 |
| 30 | Heat Treated Duralumin or 17S (US#) | 4.0 | - | - | - | - | - | Bal | 0.5 | - | - | - | 0.5 | 35.000 | 58.000 | 20 | 108 | 10 | - | - | - | 1200°F | Aircraft fabrication ditto | 174 | 30 |
| 31 | Yellow Brass | 70 | - | 30 | - | - | - | - | - | - | - | - | - | 7.000 | 23 000 | 35 | 39 | 65 | - | - | - | 2000 | Not for Construction work | 524 | 31 |
| 32 | Muntz Metal | 60 | - | 40 | - | - | - | - | - | - | - | - | - | 14 000 | 40.000 | 40 | 60 | 7.0 | 10.000 | 0.120 | - | 1900 | Forgeable Metal Yacht Fittings | 521 | 32 |
| 33 | Red Brass | 85 | - | 5 | 5 | 5 | - | - | - | - | - | - | - | 13.000 | 25 000 | 15 | 45 | 15 | 12 000 | 0.170 | 0.350 | 1900 | Steam Valves and General purpose | 542 | 33 |
| 34 | Manganese Bronze Beta | 65 | - | 24 | 0.2 | None | 2.5 | 5.0 | 3.0 | - | - | - | - | 77.000 | 108.000 | 16 | 143 | 12 | 45000 | - | - | 1900 | Highest "as Cast" Bronze as to Strength | 574 | 34 |
| 35 | " " " @ 800°F | 57 | - | 39 | 1 | 0.5 | 1 | 1 | 1 | - | - | - | - | - | 53.000 | 29 | - | - | - | - | - | 1900 | | 524 | 35 |
| 36 | " " " @ 950°F | 57 | - | 39 | 1 | 0.5 | 1 | 1 | 1 | - | - | - | - | - | 16.000 | 31 | - | - | - | - | - | 1900 | | 574 | 36 |
| 37 | Manganese Bronze Alpha Beta at Room Temp. | 57 | - | 39 | 1 | 0.5 | 1 | 1 | 1 | - | - | - | - | 30.000 | 65.000 | 20 | 110 | 20 | 25,000 | 0.04 | 0.15 | 1900 | Good for strength but not for high temp steam. | 524 | 37 |
| 38 | Ordinary Mang Br @ 1000°F | 57 | - | 39 | 1 | 0.5 | 1 | 1 | 1 | - | - | - | - | 17.000 | 18.000 | 65 | - | - | - | - | - | 1900 | | 524 | 38 |
| 39 | " " at Minus 300°F | 57 | - | 39 | 1 | 0.5 | 1 | 1 | 1 | - | - | - | - | - | 70.000 | 26 | - | - | - | - | - | 1900 | Maintains its strength and ductility at low temps | 524 | 39 |
| 40 | Aluminum Bronze | 89 | - | - | - | - | 1 | 10 | - | - | - | - | - | 25000 | 65.000 | 20 | 95 | 25 | 18,000 | - | 0.15 | 2000 | Acetic Acid Resistance · Valve Seats. | 468 | 40 |
| 41 | Lumen Metal | 10 | - | 86 | - | - | - | 4 | - | - | - | - | - | 30.000 | 30,000 | 0 | 124 | - | 25,000 | 0.015 | 0.189 | | Recommended by Lumen Co. for Bridge Turntables | 430 | 41 |
| 42 | Typical Medium Cast Iron | Sulphur 0.12 | Chromium - | Tot. Carb 3.25 | Comb C. 0.83 | - | Bal | - | 0.65 | - | 0.20 | 2.00 | - | - | 37.500 | 0 | 212-241 | - | Fails at | about | 130,000 psi | 2550 | S.A.E No 123 for Cylinder Liners | 450 | 42 |
| 43 | Typical Rly. Jurnl 4" Axle Chrome Nickel Steel. | 0.037 | 0.56 | 0.33 | - | - | Bal | - | 0.67 | 1.27 | .028 | 0.21 | - | 86.000 | 112 000 | 24.5 | 220 | 64 | - | - | - | 2800 | Highgrade Railway Axles | 490 | 43 |
| 44 | Typical Cast Steel annealed and air cooled (Normalised) | 0.03 | - | 0.25 | - | - | - | - | 0.75 | - | 0.015 | .40 | - | 40.000 | 75,000 | 28 | 160 | 25 | - | - | - | 2800 | Ordinary Casting Plain Carbon Steel. | 488 | 44 |
| 45<br>46 | To Replace Hytensil<br>" 85-5-5-5 | 85.5<br>87 | - | 3.5<br>10.0 | 6.0<br>3.0 | 6.0<br>6.0 | - | - | - | - | - | - | - | 17,250<br>11,825 | 43,150<br>43,475 | 52<br>38 | 65<br>50 | 31<br>21 | 14,000<br>12,000 | 0.138<br>0.180 | 0.305<br>0.361 | 1920<br>1940 | Same as Hytensil and 88-10-2<br>" " 85-5-5-5 | | 45<br>46 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |

Note:- Sp. Gr. of Copper is 8.91 of Iron is 7.85 - Aluminium 99.97% pure is 2.70 or 170 lbs per cu. ft
Note. Sp. Gr. or Density of P.M.G as cast is practically the same as if forged Wt. per cu. ft being 527 lbs. this is an important and favorable feature
Yellow Brass loses 80% of its tensile strength @ 932°F.
Muntz Metal " 95% " " " " @ 932°F

Drawing No. 30

Fig. 22—Physical Constants and Analyses of Non-Ferrous Alloys.

3. Cleaning of the metal surface includes not only the machining of the cast or fabricated surface, but also the prevention or the removal of any grease even such as is left by finger prints if the machined surface is handled. It is no exaggeration to say that even grease left by handling is sufficient to prevent proper tin penetration and subsequently babbitt adhesion.

4. Delay between the machining of the surface and tinning may result in the formation of a fine oxidized film hardly discernible, but which prevents adhesion. In this connection the condition of the atmosphere has a distinct bearing. In one plant bearings can be left for two or three days after machining with safety, while in a different location one must not allow allow an interval of more than twenty-four hours, less being desirable.

5. The use of sand blasting is not satisfactory as a cleaning medium. The treatment leaves a fine sand film on, or rather in, the metal that is inimical to proper adhesion.

6. The right application of zinc chloride flux.

7. There is an optimum temperature for all of the following that should be maintained if the best babbitting results are to be secured:

*a.* That of the solder.
*b.* That of the bronze back.
*c.* That of the babbitt.
*d.* That of the mould or mandril.

in addition attention must be paid to the cooling rate of the babbitt and mandril unit and the rate of pouring.

The same precautions apply to the babbitting of a steel shell.

The presence of sulphur and other occluded gases is another feature to be guarded against as it may be the cause of gas holes in the babbitt which may or may not be detrimental under the conditions of use. Methods have been devised to eliminate this gas condition. It will be seen from the foregoing that the apparently straight forward process of babbitting a bearing is not quite so simple as it may have been thought to be.

### Special Features

A few moments might perhaps be given to some special feature alloys. The engineer called for greater accuracy in measure. The linen tape varied in length according to the humidity, the incorporation of brass wire still left the alteration due to the expansion or contraction of the metallic wire, so the metallurgist provided Invar, an alloy that neither contracts or expands within a quite considerable range of atmospheric temperatures, this by alloying 36 pounds of nickel with 64 pounds of iron. The fire protection engineer called for metal that would melt below the temperature of boiling water, the metallurgist provided Woods metal, an alloy of 12½ per cent cadmium, 50 per cent bismuth, 25 per cent lead and 12.5 per cent tin, that melts at 160 degrees F., which is used to plug the water line in automatic sprinklers. The explosive engineer called for hammers and chisels that would not spark when struck. The metallurgist replied by exploding the Egyptian myth of the hardening of copper which was actually due to an unconscious alloying of tin to copper plus cold working. Such maximum hardness must have been somewhere between 70 and 135 Brinell. In its place the metallurgist offered the heat treated beryllium-copper alloy at 340 Brinell.

It is regrettable that some of the really startling optical effects in alloying cannot be shown. For instance, 200 pounds of molten manganese-bronze with all the metals in except 1 pound of aluminum will be a dirty brown colour if ingot is poured. Now add 1 pound of aluminum and the metal on ingoting is a bright golden colour, hardly believable in view of the small quantity of aluminum added.

Again, take 200 pounds of leaded-bronze, zinc 3 per cent, lead 15 per cent, tin 7 per cent, copper balance, and cast an ingot in the sand in a closed mould and the surface will be smooth and greenish brown. Add to the pot 1½ ounces of aluminum and then cast an ingot and it will be silvery white. Only about five hundredths of a percent of aluminum has been added. Repeat the experiment and add 1½ ounces of silicon, the surface of the ingot will be all worm eaten to a depth of one sixteenth of an inch and the colour will be chalk white.

Melt 1,000 pounds of battery lead, containing 5 per cent of antimony, and raise to 1,000 degrees F., the surface will be covered with an orange red liquid scum of molten oxides. Add 1 pound of tin and the orange red becomes silver colour and the molten oxide a dry powder. Only one-tenth of a percent of tin has been added.

Another example is that of the preferential attack on yellow brass by the "white water" of a pulp and paper mill. The "white water" with its various acids dissolves the zinc progressively and the alloy suffers dezincification. Only a fine wire of the original yellow brass is left surrounded by a copper rich material. The metallurgist provides a silicon-bronze wire screen for this purpose, that has no zinc content.

The engineer and the metallurgist hand in hand produce tungsten wire drawn so fine that 10 miles of it only weigh one ounce, or copper-nickel-chromium-nickel sheet so thin that it takes 500 sheets to make the thickness of an ordinary sheet of note paper. The sheets are only six millionths of an inch thick. The telephone desk set we all use has the following metals in its assembly, fourteen in all —aluminum, zinc, tin, iron, nickel, copper, silver, lead, gold, cobalt, chromium, magnesium, cadmium and palladium.

### Powder Metallurgy

Recently "powder metallurgy" has come to the fore. This is an instance of the engineer being the prime mover and the metallurgist the assistant, for while the metallurgist is necessary in order to prepare the metals used in the right form, the principle of "powder metallurgy" depends on the union of metal surfaces under conditions of extremely high compression and this compression is made possible by the ingenuity of the mechanical engineer. Various metals are prepared by reducing their oxides, casting, followed by mechanical pulverizing, or by electrolytic precipitation. The finely comminuted metals are then mixed and fed into a suitable press and given the desired form. This is generally followed by a heating process at a temperature below the melting point of any of the components and a final metallic product results strong enough to take the place of the usual cast bronze bearing of the modern locomotive, the product having a crushing strength of more than 75,000 pounds per square inch. This process has opened up the field of alloying, as it were, metals and graphite, and even metals and porcelain. The pressures required are considerable, running from 2 to 100 tons per square inch or, say, the pressure exerted by placing two of the largest loaded coal cars on each other and supporting the whole on a cube 1 inch square. The pressure required is a function of the area of cross-section and at present 6 inches diameter and 6 inches deep are the maximum possibilities.

In this paper an attempt has been made to show not only some of the relations between the engineer and non-ferrous alloys, but also to give some idea that complex problems in metallurgy are not confined by any means to the ferrous group of iron and steel.

The Roast-Newell paper contained a data sheet based on work done in a Montreal foundry by the author, to which several alloy constants have recently been added. This is now presented as a part of the present paper in Fig. 22.

Note: Figures 8, 9, 10, 11, 12 and 13 are reproduced by courtesy of the American Society for Metals.

# Modern Highway Construction in the Light of Past and Present Experience

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**Paper presented before the Montreal Branch of The EngineeringInstitute of Canada, February 18th, 1937.**

**SUMMARY.—After sketching the development of motor traffic in North America, the author discusses the various factors which should now govern highway design, having regard to the interests of the taxpayer and the motor vehicle operator.**

The relationship between human existence and transportation is such that the economic and social welfare of the people of any country, or any region, depends to a large extent on the facilities of communications available there. These facilities appraised at any period are a fair indication of the existing state of society.

The rise of the Roman Empire saw a great advance in the art of road making. Twenty-nine highways radiated from Rome into various parts of Europe, Asia and Africa, thousands of miles of improved roads reveal the degree of civilization reached at that period and, ever since, Roman roads have been symbolical of Roman culture and domination.

The succeeding period known as the Dark Ages saw these roads abandoned and, in many instances, even deliberately destroyed. Transportation reverted to pack horses. Civilization and religion declined and many kings and princes could neither read nor write. The art of road building mastered by the Romans was lost to mankind and it was not until the middle of the eighteenth century that systematic road building was again undertaken with the construction of the King's Highway in France after the appointment by Louis XIV in 1764 of Pierre Marie Jerome Tresaguet, of Limoges, to the post of assistant inspector general of public works, in charge of all roads and bridges.

The revolution interrupted the development of the national roads of France, but later Napoleon gave it new impetus by extending the main highways and building crossroads. He organized a maintenance service with a patrolman for every 5 to 6 miles of road and maintenance materials stored along the road-sides, thus inaugurating the systematic maintenance of roads.

For centuries roads and vehicles improved slowly. At first, man used his own back and arms in carrying loads as is still done today in places where civilization has not yet penetrated. Later he learned to tame wild animals and turn them into beasts of burden and, in time, he found that a cluster of branches placed under a heavy load helped when dragging it along. Gradually the wheel and then the cart came into use.

Each succeeding improvement in load carrying devices necessitated corresponding improvements in ways of communication, and finally the original trails were transformed into roads of a definite width, free of trees, stumps and boulders. However, in spite of the slow though still gradual improvement in ways of communication and means of transport, locomotion remained practically the same for ages with the horse finally emerging as the favourite among the beasts of burden.

Then about the year 1769, Nicholas Joseph Cugnot designed the first motor vehicle to be operated by steam; and in 1827 Goldsworthy Gurney of England built a steam coach capable of carrying twenty-one passengers at a speed of 15 miles per hour on level ground. Sir Charles Vance, in 1831, organized the first public conveyance system, between Cheltenham and Gloucester, and five years later, in 1836, a law was passed in England obliging all mechanically propelled vehicles to be preceded, at a distance of one hundred feet, by a man on foot or horseback carrying a red flag, and limiting the speed to four miles per hour. This law was repealed in 1896 because no law, even that limiting the speed of automobiles to 30 miles per hour, can stop the march of progress.

About the year 1830, Carter, of Newark, New Jersey, invented the buggy which later was to be manufactured by millions in the United States. R. W. Thompson, an Englishman, invented the pneumatic rubber tire in 1876, which was not accepted favourably, because a silently moving vehicle was then looked upon as a public danger. Etienne Lenoir is said to have built the first gas-motor in 1859. Gottlieb Daimler, in 1884, patented a small gas-explosion engine and Karl Benz, in 1883, built the first motor vehicle to be operated successfully. In 1880, Amédée Bollée, of Le Mans, built a steam car "La Nouvelle" which, in 1895, covered 745 miles between Paris and Bordeaux in ninety hours, an average speed of approximately 8 miles per hour.

In the United States, Charles E. Duryea built his first gas-motor horseless carriage in 1892. R. E. Olds began experimenting with the internal combustion motor in 1892 and in 1895 built his first Oldsmobile. Barnum and Bailey exhibited an automobile in their circus in 1896. A man named Winton made the first authentic auto sale in the United States, on April 1st, 1898, and this feat was considered the best joke of the time. Henry Ford began experimenting in 1890, and in 1899 started to build autos commercially. And thus, forty years ago, there began a new era in highway locomotion which, although entirely unsuspected, was to see the motor vehicle quickly replacing the centuries-old horse-drawn vehicle.

**Fig. 1—Route No. 17, between Rigaud and Ste. Anne de Bellevue, Que.**

The advent of the motor car and the first years of its development found a great difference in condition between the roads of Europe and those of North America. While many of the European countries, and France particularly, had been endeavouring for many years to improve their road communications, the United States and Canada had been primarily concerned with the development of their railway systems. In spite of this disadvantageous condition, it was nevertheless in North America that motor vehicle transport was to expand most rapidly.

The good roads movement in North America first began in New Jersey in 1891 and in Massachusetts in 1894, Connecticut in 1897, and New York in 1898. The advent of the motor vehicle, in 1896, therefore coincided with the commencement of road improvement in North America, but the motor vehicle at that time, and for some years after, did not exert any influence on this movement, whose main object was the improvement of conditions for horse-drawn vehicle traffic and was for the benefit of the farmers in particular.

In order that bigger loads might be carried on these improved roads, they followed the line of least resistance by going around hills and all obstacles that were too expensive to overcome. A highway text-book printed in 1896, states that the reason Roman roads were built straight over hills was because the movement of armies, at the time, was more important than the movement of products and merchandise, but it adds that all arguments such as the saving of time, greater loads carried or economy of maintenance, justify a somewhat longer but nearly level line. In conclusion it states that the straight line is only an abstract idea of no practical utility.

Ten years later, the number of cars had increased from 4 cars in 1896 to 107,000 in 1906. Possession of a car then was looked upon as a luxury restricted to a few wealthy city residents. When travelling by auto on the surrounding country roads one was looked upon as a tourist. Horse-drawn vehicle traffic was still the major consideration in road improvement and the idea continued to prevail that road location should be around hills rather than over them so as to follow, as much as possible, the line of least resistance. In a book entitled "Economics of Road Construction" published in 1906, reference is again made to the Roman roads and their lack of regard to topography and recommends that roads be located so that the profile will average ½ per cent grades, with a maximum of 3 per cent and, if necessary and possible, the road location be shifted so as to secure better material for both sub-grade and surfacing.

Nine years later, in 1915, the number of motor-vehicles had reached a total of 2,500,000, including 136,000 motor-trucks, and still the horse-drawn vehicle was the chief consideration in rural road improvement. In Farmers' bulletin No. 505 of the United States Department of Agriculture, the statement is again made that it is advisable to go around hills rather than over them and so obtain better grades, and it also states that "on any grade in addition to the tractive force due to surface condition, the force of gravity must be overcome. The horse must also raise his own weight and because of the manner in which his strength is applied, it becomes less and less available as the grade increases." The same bulletin, however, mentions that each year the roads were being used by a larger number of automobiles and that the motorist had done a great deal to secure the improvement of roads.

As can be seen, most of the improvements on rural roads performed up to 1915, had in view the improvement of horse-drawn traffic conditions. Curves were of short radius, and 50 feet was usually fixed as a minimum except on roads with a certain amount of motor-vehicle traffic, where the minimum was in most instances 150 feet. But the situation was soon to change, with the motor-vehicle becoming a factor of important consideration in the design and construction of roads. The increase in this mode of transportation was such that those interested in road construction began to think of its future development. Few indeed had visions of what was really to come, as shown by the statement of a well-known authority on road construction who, as a foreword to his text-book "Practical Road Construction" published in 1917, made the following forecast: "With 3,500,000 automobiles (1916) in use in the United States, it is natural that there should be the widest interest among motorists in the improvement, construction and maintenance of public highways. It is altogether probable that the ultimate number will be double those now in use." This author estimated 7,000,000 as the ultimate number of automobiles in the United States but

Fig. 2—Isle of Orleans, Typical Gravel Road.

three years later, in 1920, motor-vehicles totalled 9,300,000 including 1,066,000 trucks.

By 1920, the horse-drawn vehicle was no longer a factor of importance in the design and construction of roads, but most of the improvements of the previous twenty-five years had been introduced mainly to meet the requirements of that kind of traffic, with the result that any increase in motor-vehicle traffic made these roads less adequate for a mode of transportation for which they were not intended. From 9,300,000 in 1920, the number of motor-vehicles in North America increased to 20,600,000 in 1925 and to 27,785,000, including 3,800,000 trucks, in 1930, the first of the economic depression years.

This constant and rapid increase in motor-vehicles, and heavy trucks particularly, then equipped with solid or high-pressure pneumatic tires, was playing havoc with road surfaces which had not as yet been improved to take care of this new type of traffic. So, from 1920, the rebuilding of such surfaces absorbed much of the effort made towards the improvement of roads. Moreover, many of the old pavements had to be rebuilt in order to satisfy the new load requirement. At first many of the pavements were built only 16 feet wide, but later the 18- and 20-foot width had to be adopted on main roads.

Thirty and thirty-five miles an hour were the speed limits generally fixed by law and at first the average speed of cars did not exceed these limits. Alignments, curves and visibility for such speeds were provided in new constructions.

Year after year, however, motor-vehicles were being perfected and rendered capable of faster movement, together with better control. Speed limits began to be ignored generally without much interference by the authorities and, by 1930, the average speed of cars had reached 40 miles per hour.

From 1930 to 1934, motor-vehicle registration decreased by about 3,000,000 in North America, but still the traffic on roads continued to increase as shown by a much greater gas consumption. In 1935, registration was on the increase again and, in 1936, it had almost reached the 30,000,000 mark.

At almost any time during its development, the motor-vehicle has been ahead of the road in technical perfection, but never has this been more evident than at present. The result is that, today, vehicles capable of high speed are being driven at sixty miles an hour on 30-mile-an-hour roads. This increase in speed capacity of motor-vehicles, coupled with the large increase, not only in the total number of vehicles but also in the number of miles covered yearly, has rendered inadequate for safe and economical driving at least 90 per cent of the main highways of most countries in the world and especially those where motor-vehicle traffic has increased most rapidly.

**Fig. 3—Highway No. 6 near Matapedia, Gaspe Peninsula.**

This situation is responsible for the intensive movements taking place in so many countries for better and safer roads, roads of a standard suitable for present day traffic and that which is expected in the near future.

Canada is one of those countries where motor-vehicle traffic has developed most rapidly.

Table I

Registered Motor Vehicles in

| | |
|---|---|
| United States | 25,163,000 |
| France | 1,914,000 |
| United Kingdom | 1,814,000 |
| Canada | 1,114,000 |
| Germany | 968,000 |
| Australia | 595,000 |
| Italy | 377,000 |
| Argentina | 255,000 |
| Belgium | 198,000 |
| Russia | 180,000 |
| Spain | 177,000 |
| Province of Quebec | 171,000 |
| Sweden | 149,000 |
| Denmark | 126,000 |
| Brazil | 125,000 |
| Japan | 120,000 |
| Czechoslovakia | 116,000 |
| Mexico | 90,000 |
| Ireland | 85,000 |
| Norway | 58,000 |
| China | 49,000 |
| Portugal | 34,000 |
| Poland | 26,000 |

In the number of cars per mile of road, the Province of Quebec occupied a still higher place compared to nations having the greatest number of vehicles.

Table II

| | |
|---|---|
| Belgium | 10.5 cars per mile of road |
| United States | 8.2 cars per mile of road |
| France | 4.9 cars per mile of road |
| Quebec | 4.2 cars per mile of road |
| Italy | 3.6 cars per mile of road |
| Spain | 2.5 cars per mile of road |
| Canada | 2.0 cars per mile of road |
| Argentina | 1.6 cars per mile of road |
| Russia | 0.2 cars per mile of road |

But neither the total number of vehicles, nor the number of vehicles per mile of road, give a true picture of the intensity of traffic on the roads of a country or locality.

This is especially true of Canada as a whole and of the Province of Quebec in particular. With a neighbouring country possessing, in 1936, approximately 28,000,000 motor-vehicles, or 70 per cent of the world's total number, and with a neighbouring province, Ontario, possessing nearly 600,000 vehicles, or one vehicle to every six persons, the Province of Quebec is in an exceedingly advantageous position as regard tourist traffic. In such circumstances it is obvious that cars of outside registration form a great part of the total road traffic.

The consumption of gasoline is a much better indication of traffic intensity than the total number of vehicles registered. For example, there were 149,000 vehicles registered in this province in 1928, and 171,000 in 1936, an increase of only 15 per cent in eight years. During the same period, the gas consumption rose from 66,729,000 gallons in 1928 to 106,540,000 gallons in 1936, an increase of 60 per cent.

Considering that motor-vehicles operating on Quebec roads in 1936 averaged, as a whole, more miles to the gallon than those of 1928, it is safe to say that the intensity of traffic increased by more than 60 per cent during that period, in spite of the fact that motor-vehicle registration showed only a 15 per cent increase.

This increased traffic is due to more tourists and to a larger yearly mileage covered by Quebec vehicles.

Great intensity of traffic on inadequate roads means unsafe and uneconomical operation of motor-vehicles. The situation of the Province of Quebec, in this respect, is unfortunately no better than that of countries with higher intensity of traffic.

The latest statistics available for the United States give 827,000 accidents with 37,000 killed, 105,000 permanently injured, 1,000,000 injured and a loss estimated by economists at $1,600,000,000 for the year 1935.

The total number of accidents, persons killed and injured is evidently less in Quebec but as high, if not higher, in proportion to number of vehicles as the following comparison will show:—

United States—1 person killed for every 700 motor-vehicles
Quebec —1 person killed for every 570 motor-vehicles

There is however this difference that whereas in the United States the majority of fatal accidents occur on highways, in the Province of Quebec they occur on city streets. Unless necessary steps are taken, the situation is likely to become worse, as in the former country there is one car to every 5 persons and in Quebec the ratio is one car to every 18 persons and, consequently, is more susceptible to increase.

The Province of Ontario, with a population not greatly in excess of that of Quebec, has approximately 600,000 motor-vehicles. On the same population-registration basis, Quebec should have 500,000 motor-vehicles instead of 171,000.

Toronto, in 1935, with a population smaller than that of Montreal had 124,754 motor-vehicles. In the same proportion greater Montreal should have had 150,000 motor-vehicles instead of 71,793.

Of course there are factors which will continue to prevent motor traffic developing as rapidly in the Province of Quebec as in Ontario, one of the most important being the heavy snowfall which closes most of the highways throughout the winter. There are only some hundred miles of roads kept open in winter at present but there may be a few thousand miles before very many years.

Everything considered, it is evident that there is room for a large increase in traffic on the roads of this province. With further increases also in the number of vehicles in the United States and the provinces of Canada, tourist traffic is bound to grow. For these reasons there seems to be no exaggeration in saying that ten years from now there should be 300,000 motor-vehicles in this province, and that traffic on roads should be two to three times what it is at present.

Inadequate roads are not only costly in the number of persons killed, permanently injured, wounded and in property damages, but also in the operating expenses of motor-vehicles. With the large increase in transportation of persons by automobile and of goods and products by motor-truck, cost of operation and time of displacement, which affect the cost of transportation, have become factors of economic importance. An average saving of one cent a mile in operation on vehicles averaging 8,000 miles a year, represents an annual saving of $80 per vehicle. Shortening the Trans-Canada highway between Montreal and Quebec by ten miles would result in an average economy for passenger cars and trucks of $0.75 per single trip or $1.50 a round trip.

As already stated, the advent of the motor-vehicle and its rapid development have made the majority of the most important roads in North America obsolete as far as safe and economical driving are concerned. In the past, efforts have been directed mostly towards improving the technique of pavement construction. Expensive but durable pavements with an expected life of twenty or forty years have been laid, with the best of supervision and care, only to be either reconstructed or abandoned ten to fifteen years later because of faulty location, alignment, or subgrade.

In modern highway construction, many of the factors that were formerly either ignored or neglected must now be given first consideration. The problem of road design and construction is a complicated and difficult one, which, to be solved adequately, must be the object of thorough study by the most experienced highway technicians.

It is not only necessary that roads be designed and constructed to meet present and near-future requirements, but in order that every dollar invested may be used to best advantage they should be built in such manner that the bulk of the work performed may serve in later improvements, when such are warranted by greatly changed conditions of speed, volume and type of traffic.

Rational road planning and construction now requires, first of all, a survey of existing traffic facilities on the important highways. This survey should include consideration of the width of right-of-way, pavement, shoulders and structures; distance between and depth of ditches; nature of pavement; degree of curves and sight distances; parking facilities, sidewalks, as well as a list and description of all obstructions and hazards that may affect the speed, volume and safety of traffic.

Next, a survey of road utilization should be made for the purpose of forming a picture of traffic conditions. The maximum daily number of automobiles, trucks, autobusses and horse-drawn vehicles should be noted together with hourly, daily and seasonal fluctuations. The origin and destination of such traffic according to class of vehicle, as well as the registration by cities, villages and counties should also form part of such survey. By use of the short-traffic-count method of traffic census, the survey may be made at less cost than by methods previously employed and should be just as efficient. This survey should include the collection of all data which may serve to evaluate the probable increase, or perhaps decrease, of traffic according to type. The improvement of a road often attracts traffic that hitherto used another road, and this fact must also be taken into account. Increase in population, industrial development, tourists and the potential capacity of the people to own vehicles are other factors to be considered in the design of each highway, or section.

A survey of road accidents must also be made with the location, cause, nature and time of each accident and covering as long a period as possible must be recorded. A study of the accident survey in relation to road facilities and use will help in determining the real causes of accidents and provide for their elimination when rebuilding.

Finally, a survey should be made of all the financial resources that are presently available, or which may later become available, to carry out a reconstruction programme. It is important that those entrusted with making any programme should be informed as to the money available in order that it may be planned and carried out in a rational manner. This survey would help in determining on which roads the proposed improvements may be undertaken, and carried through immediately; the improvements that may be undertaken, but carried out in stages; and finally any improvement which must, for financial reasons, be delayed two, three or more years. It would also be useful in carrying out a maintenance programme on the roads affected, and prevent any unnecessary expenditures.

From the surveys thus made, maps may be prepared to show, in a simple way, the existing road and traffic conditions for each highway, and section of highway, and the schedule of improvements decided upon.

In highway construction, the principal elements that must be considered are: (1) speed and volume of traffic and safety of the public; (2) the comfort of the travelling public and roadside residents; (3) the aesthetics of the road. All these elements affect the design of the road and for this reason must be fully considered, each according to its importance.

In highway design, the first detail to be considered is the location of the road. The existing location should be followed wherever possible, and, if a relocation is contemplated, both the advantages and the disadvantages of the actual and proposed location must be studied and weighed. Relocation, when the existing road is not to be closed to traffic, will increase the total mileage of roads

**Fig. 4—View along Route No. 17 at Vaudreuil Hill, showing Joseph Lalonde's house built in 1827.**

and therefore the maintenance cost. However, if the advantages gained by a relocation outweigh all other considerations it should be carried out as planned for the benefit of the public.

Perhaps the most important point in road design is alignment. Many roads built in the last twenty-five years have faulty alignment, and will have to be reconstructed with the total or partial loss of still serviceable structures, foundations and pavements, which could have been made use of if the road had been better designed in the first place.

Straight sections need not be miles long, but no break should occur in a tangent unless it is justified by some serious topographical or other obstruction, or by some unfavourable condition of the subsoil that cannot be remedied. The importance of the road, and the terrain through which it runs will, of course, dictate the alignment. On heavily travelled roads, perfect alignment is a primary necessity as any slight defect in the design will reduce the traffic capacity of the road as well as its safety.

Curves should be designed so as not to interfere with the normal flow of traffic, and so as to provide sufficient sight distances. In a country with variable climatic conditions the coefficient of friction between tires and pavement is subject to sudden change, and therefore the speed at which a curve can be negotiated with safety will vary. Frequent rains, sleet and icy conditions, render dangerous curves that can be travelled safely in dry weather. The banking of curves does not remedy the situation properly, and should be avoided wherever possible by providing easier curves.

On important roads, the degree of curvature should be such that no banking is necessary for speeds up to 60 miles an hour. Curves up to 1° 30′ will fulfil this requirement and should be adopted whenever possible. On the less travelled roads, or sections of roads, curves should be as easy as possible, and in open country should never exceed 6 degrees.

In future, transition curves between tangents and the curve proper should be adopted at least on the more important roads, as they are an improvement on ordinary curves.

Width of right-of-way is another detail of road planning which should be given the best of attention. The procedure of first fixing the width of the right-of-way and then crowding in the other components of the road is not rational. The right-of-way should be sufficiently large to take care of all design requirements, such as width of pavement and shoulders, and ditches should be placed as far away from the shoulders as possible with an easy slope in between. The right-of-way, above all, should be sufficient to take care of future increases in width and design of pavement. Ribbon development or the building of residences, garages, stores and restaurants along the roadside will often take place after an important road has been improved. If sufficient space is not provided when bordering properties may be bought at a reasonable cost, it will be found extremely expensive to acquire it later on.

Grades influence the average speed of heavy motor-vehicles such as trucks and autobusses, and should be well designed. On short grades the momentum of a heavy vehicle is sufficient to carry it along without changing gear, but on long grades this vehicle may have to slow down to a speed that will interfere with the normal flow of traffic on important roads. Therefore, on highways with a large amount of heavy traffic, grades should be kept as low as possible, and should not exceed 3 per cent on long slopes. On other roads the grade may be increased, but not more than absolutely necessary. Where the flow of loaded heavy vehicles is mainly in one direction, efforts should be made to obtain easier ascending grades in that direction.

On vertical curves a sight distance of not less than 700 feet on heavily travelled roads, and 500 feet on other roads, should be provided. On three-lane pavements the sight distance should not be less than 1,000 feet. On highways where opposite lanes of traffic are divided by a central neutral zone, the sight distance may be reduced to 500 feet.

The design of the travelled roadway must be given the best of attention because the traffic capacity of a road is one of the most important factors of highway economics. Intensive observations and studies are at present being made in an effort to determine the working capacity of roadways of various width and design, and their relative safety, the working capacity of a road being the limit at which congestion of traffic becomes apparent.

Opinions differ on certain aspects of the question of roadway design, but all seem to agree that, whenever a road is important enough to be redesigned and reconstructed, the minimum number of lanes should be two, one for each direction, and the minimum width of each lane 10 feet.

What is much more difficult to determine is the maximum capacity of such a road without congestion of traffic. Many factors influence this working capacity, as for example the uniformity of speed of motor-vehicles; the percentage of traffic in one direction; the percentage of each type of vehicle, automobiles, trucks, autobusses and horse-drawn vehicles, as also the number of pedestrians and cyclists.

The working capacity of a two-lane road, twenty feet wide, may vary from four thousand to eight thousand vehicles a day. The type of vehicle and rate of flow of traffic cannot be easily controlled, but if a twenty-foot road is well located and designed its working capacity will be much greater than otherwise. On a heavily travelled road with earth shoulders, the working capacity will be increased if the width of each lane is 11 feet instead of 10 feet, giving a total width of 22 feet.

The working capacity of a three-lane highway is larger. From observations it is estimated to be about double that of a two-lane road, under similar conditions. Also, its capacity will be greater when the flow of traffic is about 70 per cent in one direction. The capacity of such roads is estimated at between ten thousand and seventeen thousand cars per day, depending on the conditions mentioned above for two-lane roads. Because of the higher average speed and volume of traffic on these three-lane roads, they should be more perfect in design and have higher standards than two-lane roads. Due to a lack of practical experience, many of the existing three-lane roads have not been properly designed for higher speeds and greater volume of traffic and many accidents have occurred that could have been avoided.

Mr. R. E. Toms, Chief of Design of the Bureau of Public Roads of the United States, made the following interesting statement at the 1936 annual highway conference of the University of Illinois: "Opinion is sharply divided as to the wisdom of three-lane construction. In the vicinity of cities, where the predominating flow of traffic is in one direction at different periods during the day, and ample sight distance is available, three-lane construction undoubtedly adds to the flexibility of movement and traffic capacity of the road. It is extremely questionable whether this is the case where approximately equal volumes of traffic flow in opposite directions at the same time. Certainly the three-lane highway is not a safe highway, and its evolution and use has been due more to the stress of economic necessity than anything else."

Mr. Toms states that the three-lane highway is not a safe highway, which is true. But neither the two-lane nor the four-lane highway are safe highways. According to Mr. A. H. Vey, state traffic engineer for New Jersey, from studies of accidents on New Jersey highways, the two-lane pavement is safer than the three-lane and the three-lane safer than the four-lane pavement. Evidently, as speed and volume of traffic increase so also does the danger of accidents. For this reason three-lane roads must be designed to better standards than two-lane roads if, for economic reasons, a much more expensive type of highway, with divided roadways, cannot be built.

Four-lane roadways have a working capacity at least three times as great as that of two-lane roads. Over the Boston Post Road, on certain peak days, the flow has reached 40,000 vehicles a day. Four-lane roads are especially dangerous at intersections with other important roads, because of the wide space that has to be crossed through a large flow of traffic. These intersections account for 19 per cent of the accidents and worst traffic jams.

Divided-lane roadways are now advocated as the best solution to the problem of reducing the ever increasing accident rate on highways. Of course accidents will always happen, whatever the perfection in the design of a road,

**Fig. 5—Highway No. 3, near Sorel. Concrete Pavement completed late in 1936.**

since so much depends on the capacity of each individual to drive a high-powered vehicle at high speed.

The flow of traffic, on a highway, has been compared to a river. Intersectional friction takes place at cross roads and accounts for 19 per cent of all accidents. Medial friction takes place in the central part of the road where the traffic flows in opposite directions. About 17 per cent of all accidents occur there. Internal stream friction is produced by traffic flowing in the same direction, close together, at different speeds. It accounts for perhaps 44 per cent of the accidents. Marginal friction occurs at the shoulder between flows of traffic and parked vehicles, trees, guard rails, telephone poles and other objects, and causes about 20 per cent of the accidents.

With divided lanes of traffic, medial friction would disappear and intersectional friction would be reduced because of the safety zone provided at the central neutral strip. To be really effective in reducing intersectional friction, the central neutral zone must not be less than 15 feet wide. These roads, however, are expensive to build, and for the present at least, cannot be built on a large scale except perhaps in states such as New York, which collects annually over $95,000,000 in license fees and gasoline tax, but which, through highway fund diversion in the last few years, has not spent more than half of this revenue on the improvement of its roads. They are more costly of maintenance, both in summer and winter, and their illumination is more expensive.

The technique of pavement construction is far ahead of other details of road design, but even expensive pavements that were laid with the best of care have soon lost their good quality, due to a faulty and unstable subgrade. A pavement is as good as the base that supports it and no better.

Intensive research and experimentation on subgrade soils have led to important discoveries regarding their characteristics and reactions and the means of eliminating or reducing unfavourable reactions. Soil science is still in its infancy, and although a lot is known much more remains to be learned.

Highway illumination is another detail that will soon find its place in the design of heavily travelled roads within a certain radius of large centres of population. Night driving has increased considerably and motor-vehicles now travel at a speed beyond the range and capacity of their lighting equipment, which explains the large increase in night accidents. Good illumination requires surfaces that will diffuse the light and not reflect it. The design of such road surfaces, for this reason, is most important.

A discussion of modern road construction would be quite incomplete if a few words, at least, were not said about the economic value of road improvement. For many years, it appeared that the chief function of highway organization was to build and maintain roads at the lowest cost possible, as long as motor vehicles were, at first, kept out of the mud and, later, out of the dust. Little consideration, if any, was given to the cost of operation of motor-vehicles and to cost of transportation. Today the situation has changed; highway transportation is now one of the most important of all human activities and cost of transportation one of the most important of economic factors.

The people of the Province of Quebec spend annually about $95,000,000 in owning and operating motor-vehicles. At least 40 per cent of this money finds its way out of the province in the purchase of motor cars, tires, repair parts, etc., a sum as large as the total revenue of the government of the province. In ten years from now this annual expenditure will be much larger. On the other hand, the average annual expenditure, in the last five years, for road improvement and maintenance in the Province of Quebec, has been approximately $12,000,000, of which not over a million a year has been spent outside of the province. It is evident therefore that the saving in cost of operation of motor-vehicles is much more important to the public in general, than the economy that could be realized in more restrained improvements and maintenance of roads.

By building adequate roads, suited to present and near-future needs of traffic, much needless reconstruction will be avoided later on, and much money will be saved. Furthermore, and most important of all, if by the rational designing of roads that have to be rebuilt, an economy of say only 10 per cent is made in the cost of operation of motor-vehicles and time saved, the annual cost of highway transportation will be reduced by that amount and an annual economy of $15,000,000 will be made possible in a few years when the total yearly expenditure will have reached $150,000,000. As a great part of this money would otherwise find its way out of the province, this economy is important.

In conclusion, it is hoped that this paper has succeeded in demonstrating that firstly, because of the continued predominance of the ages-old horse-drawn vehicle through the first twenty years of this century, and secondly, because of the tremendous and unexpected development of the motor-vehicle, too much effort has perhaps been directed towards the design of pavements, certainly not enough towards the design of other details of the road such as location, alignment, grades and widths, and too little towards such important factors as safety and cost of transportation. Highway transportation is today like an overgrown child. Up to now we have been trying to fit him with his grandfather's clothes by letting out the seams and patching here and there. It is high time that an up-to-date suit was made for him, to his measure, so that he may go about at ease and in safety.

# Some New Forms of Electrical Transmission

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**Paper presented before the Montreal Branch of The Engineering Institute of Canada, February 11th, 1937.**

SUMMARY.—Treats of a promising method of transmitting energy by very high frequency electromagnetic waves along a column of dielectric known as a wave guide. The waves are generated by an oscillator.

The forms of electrical transmission commonly used in radio and wire line practice are not the only ones possible. Actually there are many such forms and they belong to a general class which for convenience has been called wave guide transmission. A wave guide differs from an ordinary wire line in that there is no return conductor, at least of the usual kind. In some cases the guide takes the form of a hollow metal pipe and in others a cylinder of dielectric, either with or without a metal sheath.

Transmission through wave guides is possible only when the wavelength is comparable with the diameter of the guiding structure. These extremely high frequency electric waves are guided along such structures roughly as sound waves are propagated inside of a speaking tube. There are many kinds of these waves each corresponding to a particular orientation of the electric and magnetic forces in the wave front. One of these waves has a calculated attenuation characteristic that decreases as the frequency is indefinitely increased.

With an ordinary concentric conductor, such as is used for feeding a radio antenna, the outer tube forms one side of the circuit and the central conductor the other. If, however, instead of operating such a structure at a frequency of about a million cycles, approximately the average frequency for broadcasting, a frequency of two billion cycles were employed, it would be found that the central conductor could then be completely withdrawn and still the structure would be able to transmit power. It would be necessary, of course, to provide a suitable means for launching the waves, and the form of transmission would be radically different.

In this example the pipe would have had to be at least 4½ inches in diameter, but if the pipe had been filled with an insulating material having a dielectric constant of 4, a 2¼-inch pipe could have been used, while if the dielectric constant had been 9, a 1½-inch pipe could have been used. As a matter of fact, the outer pipe itself may also be done away with, and the transmission will take place along a wire or rod of insulating material, and the attenuation will be least when the resistivity of the insulator, acting as a guide, is the greatest.

Incredible as these phenomena may seem at first sight, they are readily explicable on mathematical principles that have been known for many years. As early as 1897 Lord Rayleigh obtained solutions for certain differential equations occurring in electrical theory which indicated that wave power could be propagated through either hollow metal pipes or through dielectric rods. So far as is now known, no experimental work was attempted at that early date. As often happens in science these principles were independently discovered by others. In particular, a group of workers in Germany studied this problem, and published several papers. They were Hondros and Debye in 1910, Zahn in 1916 and Schriever in 1920. Both Zahn and Schriever did a small amount of experimental work but it related mainly to the form of wave guide consisting of insulation alone, and dealt with just one of the many types of waves that may be propagated. The published literature indicates that their work was dropped at that point.

In 1931 the author resumed some experimental work on this subject, which he had started in 1920. Some of the earlier results have already been given in the April, 1936, issue of the Bell System Technical Journal.

### Nature and Properties of Wave Guides

Analysis has shown that there are many kinds of waves that may be propagated through cylindrical guides. However, four of them are of unusual interest and are such as merit special consideration at this time. All four have been experimented with in our laboratory and their more important characteristics have been determined. This experimental work has been paralleled by a mathematical analysis to which it conforms most satisfactorily.

A good mental picture of the nature of the waves propagated through guides can probably best be had by abandoning the ordinary concept of current electricity flowing in a "go and return" circuit in favour of that of lines of electric and magnetic force. This latter concept has, of course, always been applicable, even for low-frequency

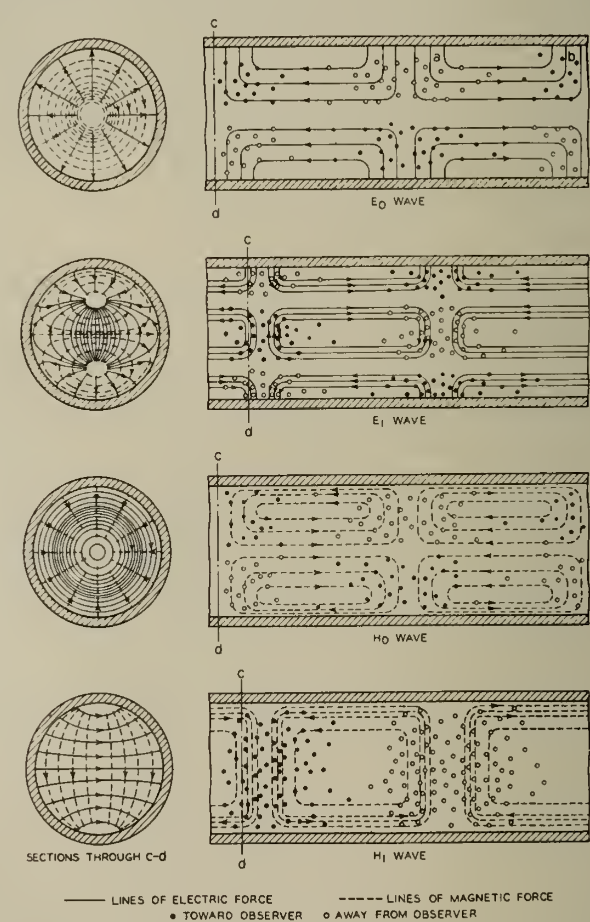


**Fig. 1—Some of the Possible Configurations of Lines of Electric and Magnetic Force that may be transmitted through a Wave Guide. Propagation is assumed to be directed to the right and away from the Observer.**

transmission over parallel wires or coaxial conductors, but due to its complexity in pictorial representation it has usually been avoided. In the form of transmission with which we are now concerned, the field point of view is almost necessary.

Figure 1 is a pictorial representation, based on this point of view, of the four types of waves mentioned above as found in a guide surrounded by a metallic conductor. In these models the lines of electric force have been represented by solid lines and the lines of magnetic force have been shown by dotted lines. In the longitudinal sections, the small closed circles represent lines of force directed toward the observer. The open circles represent lines directed away from the observer. The designations $E_0$, $E_1$, $H_0$ and $H_1$ are convenient reminders of certain characteristics of these waves.

The first two waves have been designated as electric because there is a component of electric force in the direc-

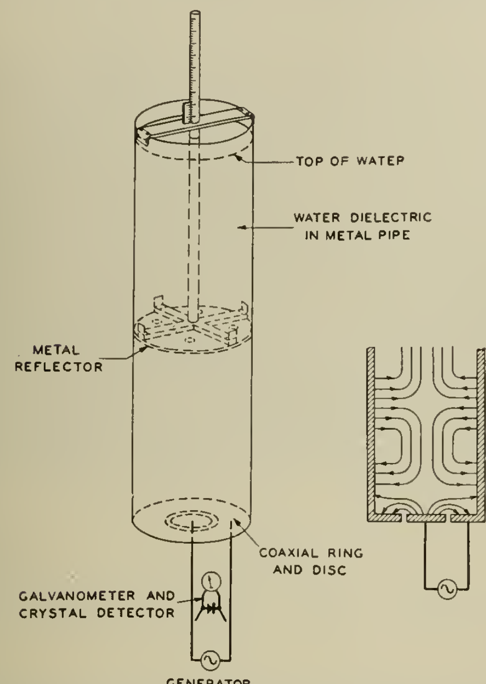


**Fig. 2—Apparatus used in Determining Fundamental properties of Wave Guides.**

tion of propagation. For similar reasons the latter have been known as magnetic waves. Such a designation is, of course, rather arbitrary and should not be construed to mean that either component resides alone. It is true here as in other forms of electromagnetic waves with which we are generally familiar, that both the electric and magnetic components are essential to the very existence of the wave

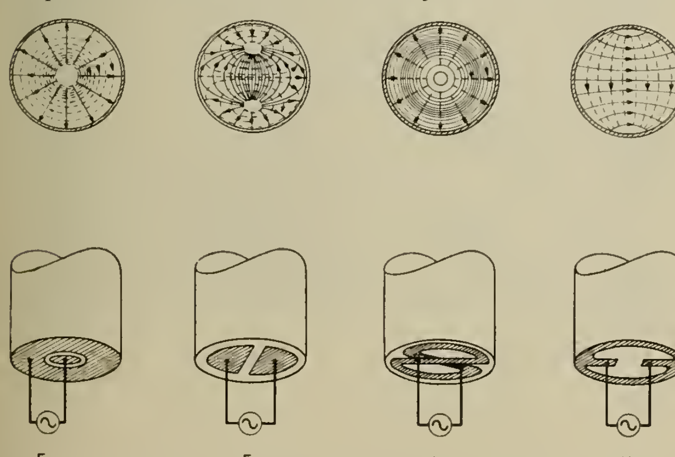


**Fig. 3—Methods of launching various types of Waves in a Guide.**

and that they may conveniently be considered as different aspects of the same thing.

Natural questions that might be asked are: (1) How do we know when these peculiar waves are present? (2) How are they launched and received? and (3) How do we know that they assume the neat configurations shown in Fig. 1? Like many other questions arising in physical science there are two answers. One is mathematical and the other is experimental. The first has already been mentioned. Some of the more crucial experiments are given below.

### Experimental Verification

The verification of the above mentioned properties of waves and their guides has involved two rather different ranges of frequencies. In the earlier work which is the particular object of this paper, frequencies between 100 and

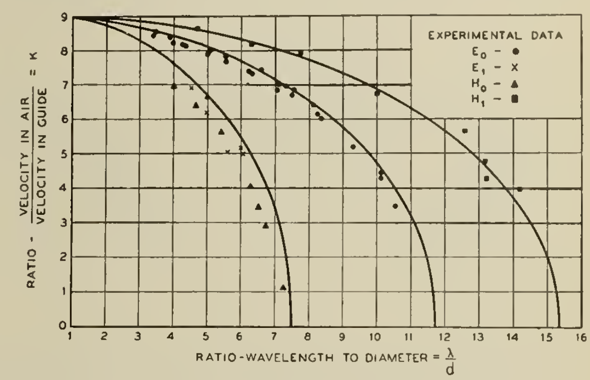


**Fig. 4—Comparisons between calculated and measured Velocities of Propagation.**

400 megacycles were used. These were obtained from a vacuum tube generator of a conventional type. The waves were propagated through cylinders of water which served as the experimental guides. More recently it has been feasible to use air core guides. However, this has called for much higher frequencies. The latter are of the order of 1,000 mc. ($\lambda$ = 30 cm.) and 4,000 mc. ($\lambda$ = 7.5 cm.). The results obtained by the two methods are, however, very similar so that the more recent work can be said to be largely confirmatory.

The apparatus used in this preliminary study is shown in very simple schematic form in Fig. 2. As already explained the dielectric guide under observation consisted of a cylinder of water. It was contained in a column about four feet long. In the course of the experiments four such columns were used. Two were enclosed in copper tubes 10 inches and 6 inches in diameter respectively, and two were within bakelite tubes of these same diameters. The bakelite was considered sufficiently thin and its dielectric constant so low compared with water that the whole could be regarded as a cylinder of water only. On account of the dielectric losses present, water would not ordinarily be considered a good medium for a wave guide but because of its high dielectric constant it was excellent for the simple experiment at hand.

The shape of the conductors on the launching mechanism determined the type of wave produced. When the $E_0$ type of wave was desired this pad, as it was called, took the form of a metal disc surrounded by a metal ring. The two wires leading from the vacuum tube generator were connected to the disc and outside ring, respectively. If other types were wanted pads were used made up of other electrode arrangements as illustrated in Fig. 3 below.

Loosely coupled to the lead wires from the generator to the pad was a crystal rectifier and a d.c. microammeter. This indicated in a rough way the relative power passing into the wave guide. It was sufficiently sensitive that any reactions from the wave guide back onto the generator were accompanied by rather marked changes in the meter deflections. By suitable reflections in the wave guide standing waves could be set up which gave rise to maxima and minima readings in the meter.

Standing waves were produced in the water column by three rather different methods. Substantially the same results were obtained by all. In one case water was admitted slowly to the column. As the level of the water rose the deflection of the meter varied periodically through rather wide limits, indicating points of resonance in the column with a corresponding absorption of power from the generator. When the coupling between the column and the parallel wire circuit could be made small, the reaction between the two was also small except at points close to where absorption took place. This method is very similar

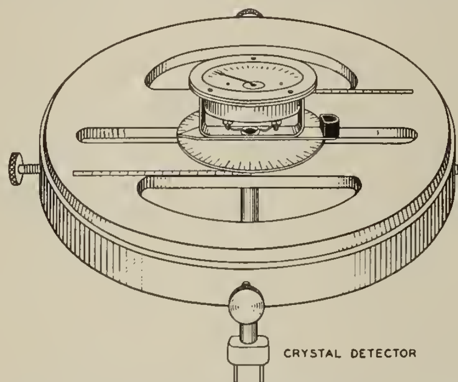


**Fig. 5—Apparatus used in Verifying the various Configurations of the Lines of Force shown in Fig. 1.**

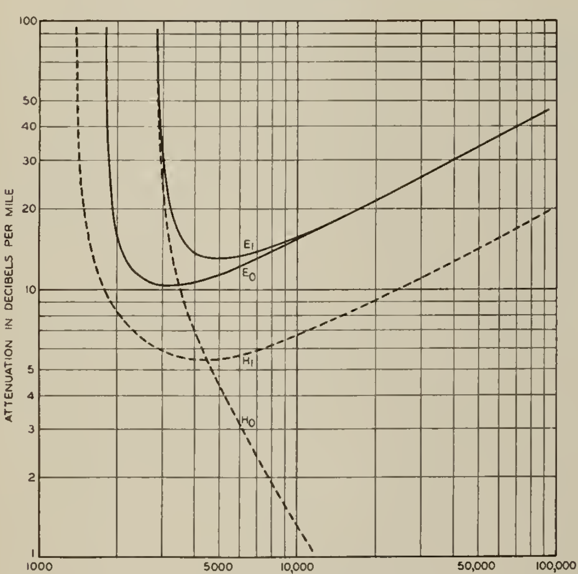


**Fig. 6—Calculated Attenuation Characteristics of a 5-inch Hollow Copper Pipe.**

to the scheme that is sometimes used in radio measurements whereby resonance in a secondary circuit is indicated by absorption in a primary. In this experiment the distance between successive absorption points was taken as one-half of the wavelength as measured in the medium.

These simple experiments not only showed the existence of electric waves but they also gave data relating to their velocity of propagation. The difference in water level between alternate maxima and minima gave the wavelength as measured in the guide. Previous determinations of a slightly different sort had given the frequency of the generator. Velocity could then be calculated in the usual way by multiplying wavelength by frequency.

Measurements of this kind were made on all four types of waves. The resulting data for the case of the shielded guide are plotted as points in Fig. 4. The solid curves were calculated from the mathematical theory. It assumed that the correct dielectric constant of water is eighty-one. In order to include on the same sheet data for different diameters of guide there has been plotted as abscissae the ratio of wavelength to diameter. Also it has seemed desirable to plot instead of velocity in the guide, its ratio to velocity in free space. The approximation between measured and calculated results is evident.

The configurations of the lines of force in a wave guide were verified by means of probe measurements similar in principle to those sometimes used in verifying the magnitude and direction of the magnetic flux near the poles of magnets. Figure 5 shows the details of both the probe and its bakelite mounting. The latter was clamped to the top of the water column and adjusted so that the probe wires just reached the water. The probe could rotate about its axis as well as be moved laterally along the slot shown. The part carrying the slot was also free to rotate with respect to the column so that the entire surface of the water could be investigated. The two rotating parts were laid off in degrees and the slot carried a centimeter scale.

In exploring the field of a pure $H_1$ wave it was readily verified that the lines of force were chords generally parallel to the plane of the lead wires from the generator (shown schematically in Fig. 3). When the probe was carried across the diameter along which the electromotive intensity was applied, the deflection was optimum only when the line connecting the probe wires was kept parallel to this diameter and was zero or very small when oriented at right angles thereto. When the probe was carried along the diameter perpendicular to that in which the electromotive intensity was applied again the deflection was optimum only when it was parallel with the electromotive intensity. At points near the wall there was a definite tendency for the optimum position to be radial. This is of course in keeping with the idea that small areas of conductors may be regarded as equipotentials.

**Fig 7—Experimental Wave Guides shown in testing the Mathematical Theory of Guided Waves.**

For the $E_0$ type of wave the probe meter read a maximum when the line connecting the two probe wires was radial and a minimum (usually zero) when it was tangential. Similar measurements on the $H_0$ type of wave gave nearly opposite results for it was only when the line of the probe wires was kept tangential that the readings were a maximum. No great effort was made to verify the shape of the $E_1$ wave. However, it was not difficult to establish the two null points that are evident from the configuration shown in Fig. 1.

### Attenuation

Wave guides behave somewhat like wire lines in that they have a definite characteristic impedance and a definite attenuation. The calculated attenuations of the four principal waves are of particular interest. They are shown in Fig. 6 for the special case of a five-inch hollow copper pipe.

It will be noted that all waves suffer infinite attenuation at or below certain critical frequencies, and that with an increase in frequency this attenuation decreases very rapidly. For three of the types of waves it approaches a minimum, and then increases for higher frequencies. For the wave that has been designated as $H_0$ this attenuation appears to decrease indefinitely with increase of frequency.

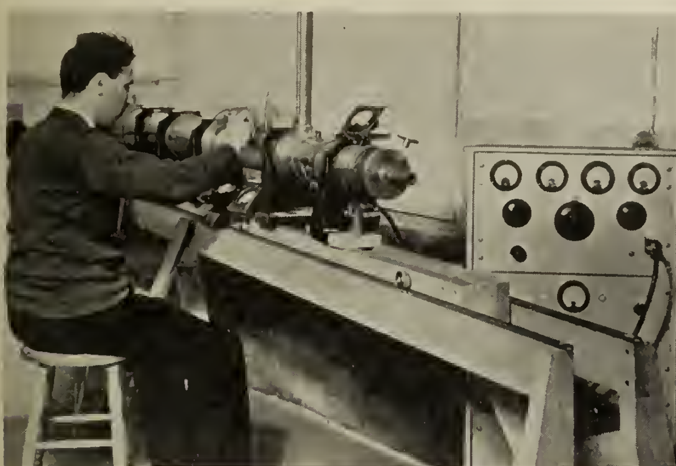

Fig. 8—Transmitting end of Experimental Wave Guide.

Not all of the calculated characteristics of wave guides have yet been verified experimentally. In particular, relatively little information is yet available on the very interesting $H_0$ wave except near cutoff. At present, work is being done at the Holmdel (New Jersey) Radio Laboratory directed at measuring these attenuations. For this purpose two hollow copper pipes are used, which are four inches and six inches in diameter and 1,250 feet long. These pipes are shown in Fig. 7.

The experimental results to date indicate that the attenuations may be calculated with reasonable accuracy and that they are not in general as great as for ordinary wire lines operated at these frequencies. Figures 8 and 9 show respectively the transmitting and receiving apparatus used in the attenuation measurements. Details of this apparatus are outside the scope of this paper. However, certain of its features will be evident from some of the fundamental principles that are mentioned below.

### Wave Guide Apparatus

An interesting technique is being built around these new forms of transmission. In much the same way that a pair of wires may resonate to waves travelling along their length, or an air column may resonate to certain sound waves, so may a short section of wave guide be made to resonate electrically to the frequencies which it is able to propagate. In its role as a resonator it behaves as if it were a coil and condenser, sometimes in series with an electromotive force, and sometimes in parallel. These resonance effects are very pronounced and may be simply demonstrated by a cylindrical chamber such as that shown in Fig. 7. This figure shows the author holding one of the resonant chambers used for tests of wave-guide transmission. Behind him are the two experimental transmission lines.

In its role as a tuned circuit, the resonant chamber is sometimes used as a wave-meter, sometimes in connection with a generator of short waves (thereby enabling a vacuum tube to work more effectively) and sometimes as an element in a receiver (thereby impressing on a detector a maximum of the received wave power).

The open end of a guide may be made to radiate wave power much the same as sound waves issue from a pipe. To enhance this effect the pipe may be expanded into a cone, thus producing an electrical horn. Tests show that it may function much the same as an acoustical horn, and accordingly may be used as an efficient radiating load for the generator to which it is connected.

### Generators

One arrangement for generating the $H_1$ type of wave consists of connecting the primary source of waves between diametrically opposite points on the inside of a hollow cylindrical conductor as shown by Fig. 10 (a). This primary source may consist of a positive grid (Barkhausen) tube or a magnetron.* Both have been used successfully to give frequencies up to about 3,330 mc. ($\lambda = 9$ cm.).

A typical arrangement of such an oscillator is shown in Fig. 10 (b). The terminals of the spiral grid of the Barkhausen tube are connected to diametrically opposite points through a suitable by-pass condenser. The filament and plate leads enter along a plane perpendicular to that of the grid. Since the grid leads correspond to lines of electric force in the generated wave, the diametral plane perpendicular thereto corresponds to an equipotential. By locating the plate and filament leads in such an equipotential, their presence will not materially affect the normal field prevailing in the chamber. In the design shown the filament connectors constitute the outside plates of a three-plate-by-pass condenser. The third or central plate is a rigid member grounded on the main guide. It connects to the plate of the Barkhausen tube. Connections to the exterior are had through five insulated binding posts. The oscillator unit shown carries on its exterior a plug connector leading by cable to a nearby d.c. power supply unit.

Fig. 9—Receiving End of Experimental Wave Guide.

If an oscillator similar to that described above were connected into the middle of a long hollow pipe, waves would, of course, be propagated in both directions. Those that would ordinarily be propagated to the left may be reflected by a suitably located reflecting wall or piston so as to reinforce those being propagated to the right. Also

*"Vacuum Tubes as High-Frequency Oscillators," M. J. Kelly and A. L Samuel, B.S.T.J., Vol. 14, p. 97, January 1935.

an iris of suitable proportions may be so located in front of the generator as to further enhance oscillations. As has been pointed out above the section of pipe bounded by the piston and iris together approximate in behaviour a tuned circuit. It is convenient to regard the chamber as a load impedance characteristic of the tube itself or perhaps it should more properly be regarded as a transformer by which the oscillator is matched to the line.

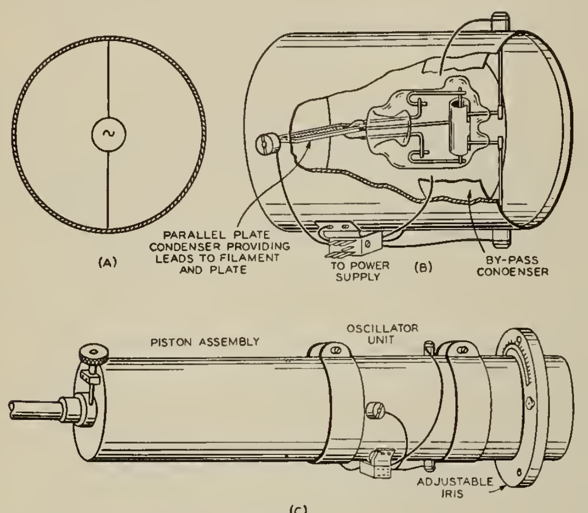


**Fig. 10.—Various Component Parts of a Wave Guide Generator. (a) Schematic representation of Connections. (b) The Oscillator Unit. (c) Complete Generator including Oscillator, Iris and Piston.**

### Possible Applications

The question naturally arises as to what use wave guides may be put. This is a difficult question at this early day. Wave guides have definite limitations. The diameter of the hollow pipe that may be used is directly proportional to the wavelength. For a pipe that is at all convenient in size, the frequencies are the highest that have yet been tried out for radio. It is true that the diameter of pipe might be reduced if it could be filled with a suitable insulator. However, at this point we are met with a conflicting difficulty of producing at reasonable cost the necessary medium that will incorporate high dielectric constant with sufficiently low losses. It is true too that low attenuation could probably be had with much smaller pipes by the use of $H_0$ waves, but this calls for an even higher range of frequencies. For long-distance transmission, the situation is that the art at these extreme frequencies is not yet at a point which permits a satisfactory evaluation of practical use. For transmission over very short distances, however, or for use as projectors of electric waves, or as selective elements under certain conditions, the use of wave guides has definite possibilities.

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# Air Conditioning in a Northern Climate

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**Paper presented before the Montreal Branch of The Engineering Institute of Canada, on October 8th, 1936.**

**SUMMARY.—The paper deals with the advantages and limitations of air conditioning in summer and winter in Canada, and gives some typical results as regards operating conditions, comfort and power required.**

In these days one is likely to hear many people speak of air conditioning as "the coming thing" or "the next big industry." Although these statements are often made casually and without study, they do indicate a general belief that this new industry offers something of real value. Since the permanent growth of an industry is basically related to the benefits which it produces, it is well to examine more specifically the contribution to our well-being which air conditioning offers, and something of the technique by which the results are obtained. What does one seek to gain by conditioning the air of homes, stores, offices and trains?

Probably foremost is the control of temperature, utilizing heating or cooling to avoid extremes. However, this control need not produce a dead level of constant temperature, which would probably be monotonous. There is good evidence that the frequent variations of a northern climate produce a stimulating effect, although the extremes also cause much physical wear and tear. Hence the method of control should remove the extremes of heat and cold and yet allow some latitude in the choice of temperatures to suit activity and bodily condition.

Control of humidity is also becoming recognized as important. The humid days of summer depress one as badly as the extreme heat in the prairie states, which is not accompanied by high humidity. In winter the dryness of the winter air, when heated in the home, does not represent a normal condition; and the extreme dryness is not healthful. Here again, air conditioning enables one to avoid the extremes.

Still another factor is that of normal air circulation to prevent the air from settling into hot and cold strata. In houses or offices where there is no forced circulation of air, or where the circulation is not properly directed, it is not uncommon to find ten degrees temperature difference between air at the floor and air at the breathing height.

Circulation of air also helps to dissipate odours, particularly if enough new air is constantly being brought in. Of course, in many of the older houses, adequate ventilation is more than assured by the steady in-leakage of air around windows, doors, and even through the walls. In the newer construction, insulated, weather-stripped, sealed, this leakage is greatly reduced, and mechanical ventilation may actually be needed to prevent staleness. In either case, it is desirable to be able to bring in most of the ventilation air at one point, distributing it as needed rather than allowing it to leak in irregularly and disturb the control of temperature.

Some means for cleaning air should be a part of any air conditioning system. The various types of filters available are classified as to capacity—which determines the frequency of cleaning or replacement—and as to dirt-catching efficiency, which may vary from 60 to 95 per cent for various sizes of dust particles commonly encountered. In applying air conditioning to homes already clean and well-kept, it has been found that immediately after installation the filters become filled with dirt in two or three weeks. This represents the accumulation not only in the air but on walls, furniture, and draperies which is not easily removed by ordinary methods. After this initial "house cleaning" by an air conditioning system, six months may elapse before the filters again require attention.

Then there are certain collateral advantages of air conditioning which, in the opinion of the author, have not adequately been recognized. A well-planned system can do much to shut out noise and odours—both of which are irritant and tend to reduce working efficiency. Equipment and the installation technique have now reached a point where little or no sound reaches the occupants from the air conditioning plant itself. Many a building manager can recite the difficulty of renting the lower floors of an apartment or an office building facing a busy street. If the windows are opened, the occupants must put up with the street noise, but with closed windows, and a separate source of fresh air, most of this outside noise can be kept out. Furthermore, the gasoline fumes and dirt from the street may be eliminated, since the fresh air for ventilation may be drawn in at the other side of the building, or from a shaft extending above the roof, or any location most free from contamination.

The relative importance to be given to all these phases of air conditioning depends, therefore, not only on the climate but also on the immediate surroundings of a building and on the conditions of occupancy within the structure itself.

In this climate, there is no question of the need for winter air conditioning, that is, the proper control of temperature and humidity, and the cleaning and circulation of air. In heated buildings, a relative humidity of 40 per cent is desirable. For hospital operating rooms, even higher humidities of 50-60 per cent are sometimes called for, to reduce the possible hazards from sparks of "static" and to improve conditions for patients who may be in a weakened state. Actually, however, the degree of moisture which may safely be added to the air is often determined by the building construction. A tightly-constructed building, particularly with double glass windows, can usually be maintained at 40 per cent relative humidity even in severe weather without danger of condensation. In poorer construction, it is often necessary to restrict the humidity on cold days to 30 or even 25 per cent, not only to avoid the formation of frost on the windows, but also to insure against condensation where cold air pours in through cracks, or circulates through thinly built walls.

Of the various types of humidifiers available, some simply discharge fine water particles in a moving stream of air, leaving the real evaporation to be completed as these particles are discharged into a room. In other devices, heat is applied to convert the water to water vapour in the air before it is discharged. Humidifiers of the latter type are safer, since the evaporation is assured, and local condensation does not occur unless the warm humidified air is discharged close to a cold wall or window. In the author's experience, it has been found desirable to go a step farther, and actually heat the humidified air above room temperature before discharging it. A stream of air at 70 degrees feels cold to most people. Hence a humidifier should preferably discharge air at 85-90 degrees, to avoid the criticism of producing a cold draft. Figure 1 illustrates the application of a humidifier of this type. Air withdrawn

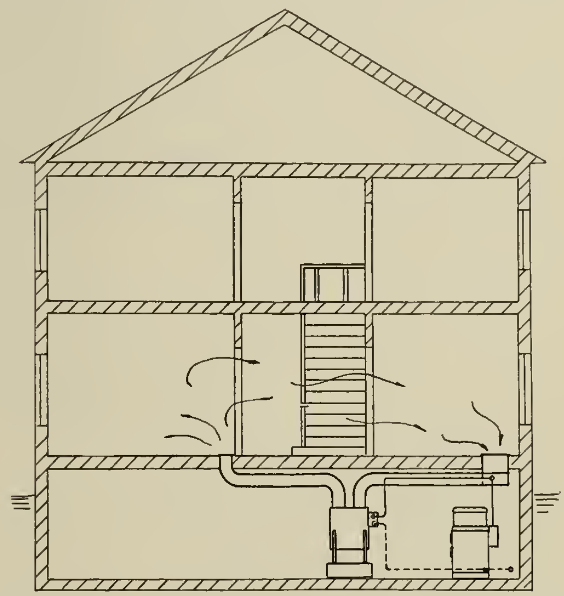

**Fig. 1—Typical Installation of Winter Air-Conditioning for House with Radiator Heating, illustrating Heating Connections and Method of Air Distribution.**

through a duct at one side of a house is brought to the device, heated, filtered, humidified, and then discharged through a duct to some adjacent room. Thus the humidifier cleans and circulates the air as well. For rooms not in the direct air circuit, the vapour pressure assures even distribution of moisture, and this spreading takes place quite independently of the circulation of air.

Where summer air conditioning (i.e. cooling, drying, cleaning, ventilating and circulating) is in question, the need is determined more than ever by the immediate locality and by conditions of occupancy. Some examples may emphasize this statement.

Here is the summary of the cooling load of a restaurant which was recently air conditioned in a nearby city. Although higher temperatures sometimes occur, the load was calculated for outdoor conditions of 90 degrees dry bulb and 74 degrees wet bulb. These same conditions incidentally are frequently used as a basis for design in Montreal.

| | B.t.u. per hour | |
|---|---|---|
| *Removal of Sensible Heat* | | |
| Conduction through walls, windows, etc. | 6,000 | |
| Sun effect | 0 | |
| Ventilation air | 12,500 | |
| From 100 occupants | 22,000 | |
| From appliances | 30,600 | |
| | | 71,100 |
| *Removal of Latent Heat* | | |
| From ventilation air | 8,600 | |
| From 100 occupants | 18,000 | |
| Estimated evaporation from food, coffee, etc. | 3,000 | |
| | | 29,600 |
| Total | | 100,700 B.t.u./hr. |

Here, only a small part of the heat load or the moisture load results from the outdoor condition, in fact only 25 per cent; by far the greater part is generated within the restaurant. There is no question but that such a condition justifies the installation of equipment to reduce both the temperature and the humidity, even in fairly mild weather. Without air conditioning, the temperature in this restaurant would (and did) frequently exceed 100 degrees F.; and this temperature, combined with a high humidity, would make it difficult for anyone to enjoy even the best of food. Ventilation alone might have been supplied to give some

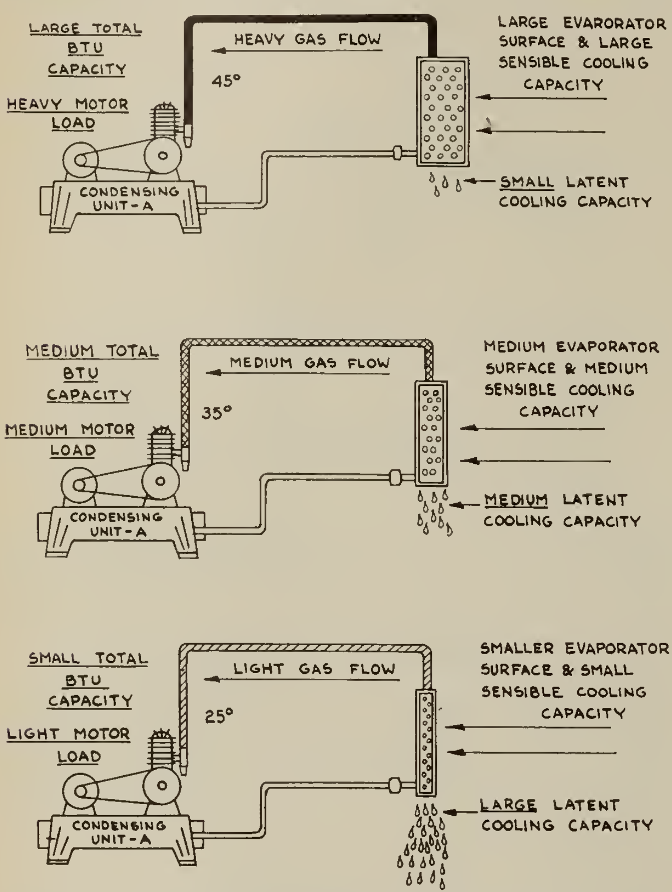


**Fig. 2—Selection of Equipment for Central Plant Air Conditioning Systems.**

relief. But calculations indicate that even if a temperature 5 degrees higher than outdoors was accepted, an excessive air flow would be needed to carry away the heat, producing drafts and still leaving the humidity uncomfortably high. Therefore, complete summer air conditioning became a necessity if the restaurant was to be attractive to its patrons and profitable to its owners during the summer months.

Another example may be worth mentioning, since it is typical of a situation which all have seen. In a northern city studies were recently made of an office building which houses the central office of a national concern. The building is rather long and narrow, and relies on windows at front and rear for air and for natural light. Even with windows open, the ventilation in summer has been inadequate. On windy days, those nearest the windows must tolerate the scattering of papers, if the others are to get any fresh air. Close work with ledgers and records has required the addition of a large amount of artificial light, which produces a considerable amount of heat. On the top floor, skylights eliminate much of the use of artificial lighting, but the direct rays of the sun produce even more intense heat. Even though this city does not experience many sweltering days, the owners of this building have recently made a substantial investment for a year-round air conditioning plant. They anticipate that the more uniform and comfortable conditions and the absence of drafts will reduce the time lost through sickness, enable more work to be done with fewer errors, and prolong the useful life of their building; and by no means least important, they expect from their employees a favourable mental reaction for this gift which enables them to work under more comfortable and healthful conditions.

Many more cases could be mentioned where the need for cooling goes far beyond the occasional hot day—crowded theatres, which really need cooling until the outdoor temperature drops to 50 degrees; beauty shops, where the many curling and drying appliances produce nearly half the heat needed in winter; hospital operating rooms, where the sterilizing equipment, the intense light, and the quick activity of the several doctors and nurses produce a degree of heat and humidity both uncomfortable and sometimes unfavourable to both the patient and to the efforts of the surgeon. It is significant that many hospitals are conditioning the air of their operating rooms, and that this activity is not restricted to the southern cities with their longer summer seasons.

In the design and installation of air conditioning systems many problems arise, particularly in older buildings for which air conditioning was not planned at the outset. A large proportion of the cost arises from attempting to work the system into the building in such a way as to avoid disfiguration and to avoid injuring the structure. In a department store, all equipment might be placed in a central machinery room, and ducts run to the various floors. This is sometimes done, although the tearing up and redecorating involves considerable interruption of business. But the arrangement and use of successive floors may not be suited to a simple repeated pattern of risers and return ducts. So one must consider the alternative of having the heat-generating and the cooling equipment in a central plant, and connected by pipes to several smaller air conditioning units serving limited areas. Not only the space arrangement, but also exposure, internal heat load, sources of odours, or differences in noise level can then be considered for the individual spaces, and designs made accordingly.

In an office building, space is often conditioned for one tenant, occupying part or all of a single floor. If on an upper floor, it may be necessary to reserve a space for equipment adjacent to the conditioned space. Here the choice and location of equipment must take into account the location and size of power feeders, water and drain lines. The distribution of air must be planned with an eye to the possible rearrangement of partitions and offices, to make the system as flexible as possible.

A problem most carefully studied is the distribution of the heating or cooling effect to spaces having unlike exposures or variable loads. A west room may require little cooling until afternoon, and then develop a heavy load; for an east room, just the opposite; the tap room or tavern of a hotel may become crowded in the evening, when other parts of the system are only slightly in need of cooling. Rooms with a north exposure may require the least summer cooling but the greatest amount of winter heating. Of course, these requirements can usually be anticipated. They must be dealt with not only as to the provision of maximum cooling or heating capacity, but also as to suitable control. As far as practicable, spaces having similar requirements are combined into one zone or division of the plant. The rate of air flow may be controlled by dampers, although too great reduction impairs both ventilation and air distribution. With separate heat transfer surfaces, continuous air flow may be maintained, and the degree of cooling or heating modulated to meet varying requirements; or part of the air may be passed through the heat transfer surface, and the rest deflected around. All of these methods and others may be utilized in meeting widely different requirements in parts of the same system.

The design of an air cooling system should always be calculated to produce adequate air drying. Too many systems, improperly proportioned in this respect, produce a cold, clammy sensation, as of entering a cave. The moisture to be removed is not only that which enters with the ventilation air, but also that generated by people and processes in the space. The degree of moisture removal obtainable is governed by the coldness of the cooling surface. Figure 2 attempts to illustrate the relationships involved. With a relatively high temperature of refrigerant (and with adequate cooling coil surface) a given system develops its greatest capacity, but with only a small air-drying effect; conversely, a low refrigerant temperature reduces the total capacity, but permits more condensation of moisture, with a smaller coil surface. Usually, for comfort cooling installations, the average case is about right, using a refrigerant temperature of 35 to 40 degrees F., with the result that 25 to 35 per cent of the total plant capacity is used for dehumidification.

These relationships are easily shown on a psychrometric chart (Fig. 3). Let us assume a case where the indoor condition is to be 80 degrees with 50 per cent relative humidity and the outdoor is 91 degrees with 74 degrees wet bulb temperature; also that one-third of the total circulation represents ventilation air drawn from out of doors. If this air is mixed with the recirculated air before entering the conditioner, the temperature and moisture content of the mixed air will be indicated by a point on a straight line between the indoor and outdoor points—in this case, at 83.7 degrees, since the greater part of the air is recirculated. In order to be able to absorb both the heat and the moisture generated within the room, the air leaving the conditioner must be colder and drier than the nominal room condition. In the case of the restaurant described above, with a total air circulation of 3,500 c.f.m., air would have to leave the conditioner at 65 degrees and with moisture content of 67 grains per pound. Connect by a straight line the points representing "air entering" and "air leaving" the conditioner, this line extended to its intersection with the saturation curve will indicate the temperature of the cooling surface which must be used to produce the respective proportions of air cooling and air

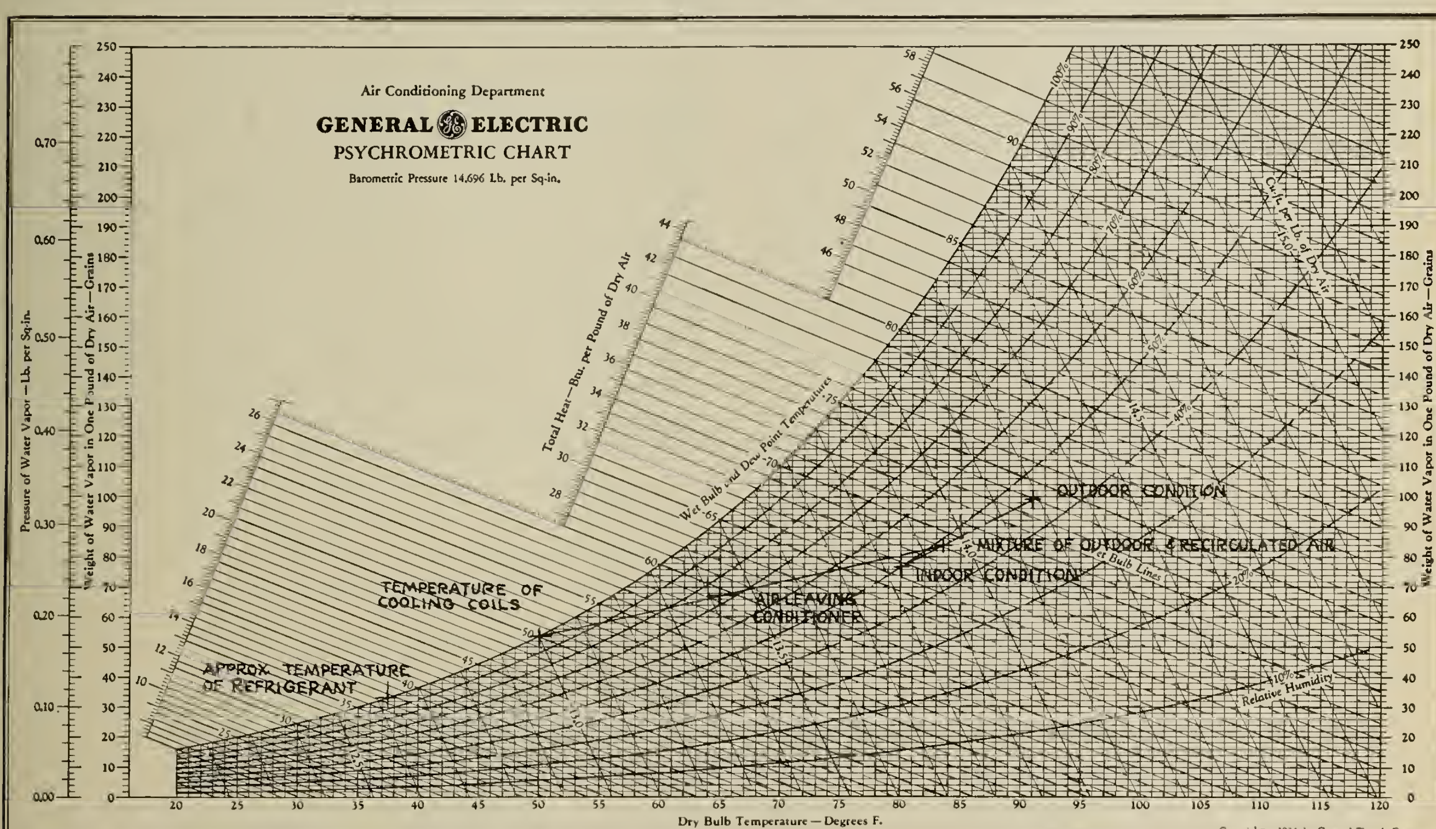


**Fig. 3—Psychometric Chart.**

Note.—If two properties of air are known, all properties may be found as follows:

Dry Bulb Temperature is read directly by following vertically down to the bottom scale.

Wet Bulb Temperature is read directly at the intersection of the wet-bulb line with the 100 per cent relative humidity line (saturation curve). The scale is marked along the 100 per cent line.

Relative Humidity is read directly from the curved lines marked Relative Humidity. For a point between the lines, estimate by distance.

Moisture Content, or Absolute Humidity, is read directly from horizontal lines with scales to the right and left of the chart, and is the weight of water vapour contained in a quantity of air and water-vapour mixture which would weigh one pound if all water vapour were extracted.

Dew Point Temperature is read at the intersection of a horizontal line of given moisture content with the 100 per cent relative humidity line.

Total Heat is read directly by following the wet bulb line to the scale marked Total Heat. Total heat refers to a quantity of air and water-vapour mixture which would weigh one pound if all water vapour were extracted, and includes the heat of the water vapour.

Specific Volume is read directly from the lines marked Cu-ft. per lb. of Dry Air. For points between lines, estimate by distance. Specific volume is the volume occupied by a quantity of air and water-vapour mixture which would weigh one pound if all water vapour were extracted.

Vapour Pressure corresponding to a given moisture content is read directly from the left-hand scale marked Pressure of Water Vapour.

drying required; in this case, a surface temperature of 50 degrees, corresponding to a refrigerant temperature of about 38 to 40 degrees within the coils. This straight line relationship, which should be a part of every cooling calculation, but which is so frequently neglected, furnishes an easy basis for making sure of adequate air drying along with the cooling process.

The electric load aspects of air conditioning have been carefully studied by many of the electric utilities, as well as by the manufacturers. For winter air conditioning, the electrical demand is small, in keeping with the existing load of lights and small appliances. Its load factor is good, since an automatic heating system may operate more than two thousand hours during the heating season, and the operation of air circulating equipment is at least as much, if not actually continuous.

For summer cooling, the operation of motor-driven compressors involves a larger demand—approximately 3 to 5 kw. for complete cooling of an 8-room house—and the number of hours of operation is smaller. Fortunately, however, this load occurs in a season when the load of a power system is likely to be lowest; and from an hourly standpoint, it occurs mainly during the day and drops off before the evening lighting peak begins. As it becomes possible to study the combined electric load of many installations, it is reasonable to anticipate a considerable diversity in the time of peak demand, due to both occupancy and building construction. For the cooling of homes, the peak demand occurs in the late afternoon; for theatres, generally in the evening, when the attendance is greatest. Even among homes, the electrical diversity factor will be marked, since some houses of light construction follow rapidly the outdoor temperature changes, whereas heavily built or insulated houses respond after a time lag of several hours. Therefore, although some individual distribution lines will have to be enlarged, the overall effect of a large residential and commercial air conditioning load appears to be a favourable one.

Looking broadly at this subject of air conditioning which has lately engaged so much attention, one can draw a few conclusions as to its future effects, as it becomes more widely applied. The effects of air conditioning are not spectacular and, in fact, the operation is most successful when it permits us to be unconscious of our atmospheric surroundings, rather than acutely aware of them. Although not a panacea, and even though the name "air conditioning" is still being applied to many devices of the "gold brick" type, air conditioning equipment properly applied has a wide field of usefulness. In its various phases, air conditioning offers improvements towards comfort and health, substantial relief in many cases to hay fever sufferers, and is a sound investment for many types of business which serve the public by direct contact.

The cost of air conditioning will be lowered somewhat as the designs of new buildings are modified to aid the installation, and as those engaged in planning new structures become more accustomed to considering air conditioning as an integral part of a building, rather than as an appendage. In return, the advance of air conditioning is helping the architect and the builder to secure public realization of the advantages of better building materials. The author has seen many cases where insulation, better window frames, better wiring, and even structural improvements have been adopted after their advantages had been seen from the particular standpoint of air conditioning.

A considerable amount of statistical evidence is becoming available, showing that, where one can work and live in greater comfort and avoid the mental and physical annoyance of noise, dirt, drafts, and sudden changes of temperature and humidity, the output of productive work is increased. And such measurements, most easily obtained among groups performing routine work, might logically be assumed to apply also to those engaged in more creative types of work which require the greatest mental energy and concentration.

Probably the best index of the widespread future use of air conditioning lies in the extent to which it has already been adopted as a sound investment by many industries, not only to facilitate manufacturing processes and improve products, but also to improve working conditions for employees in shops and offices alike.

## A.S.M.E Semi-Annual Meeting—Detroit, May 17-21, 1937

As announced last month, the general programme of the American Society of Mechanical Engineers meeting at Detroit will be based on a series of six sessions at which authorities from engineering and industrial fields in the Detroit area will develop a broad survey of modern techniques employed by mass production industries, typified by the building of automobiles. In addition, simultaneous sessions of the professional divisions of the Society will provide opportunity for the presentation and discussion of papers along the lines of their special interest.

*The members of The Engineering Institute of Canada have been invited to participate in these activities, and will be made welcome at any of the technical sessions or functions which they wish to attend.*

Monday, May 17th—Registration, business meetings and inspection tours.

Tuesday, May 18th—

9.00 a.m. The Scope and Purpose of the Planned Programme, C. F. Hirshfeld.
Historical Sketch Contrasting the Practice of Automotive Design and Production with Methods in Older Engineering Fields, C. F. Hirshfeld and E. H. Piron.
Modern Locomotive and Axle Testing Equipment, Tracy V. Buckwalter O. J. Horger, and W. C. Sanders.

2.00 p.m. A Year of the New Apprenticeship in the Detroit Industries, Chester W. Culver.
Organization and Growth of the Future Craftsmen of America, J. Lee Barrett.
Design, Construction and Operation of Springwells Station of the Detroit Dept. of Water Supply, W. C. Rudd and B. J. Mullen.
The Separation and Removal of Cinder and Fly Ash, Arthur C. Stern.
Incinerators—Municipal, Industrial and Domestic, H. F. Hersey.
Industrial Power Plants, E. Boomhaur.
Industrial Heating and Process Furnaces, E. F. Holser.
The Contribution of Broaching to the Automotive Industry, Sol Einstein and Millard Romaine.
Industrial Bearing Design as Influenced by Automotive Practice, A. B. Willi.

8.00 p.m. Recent Developments in the Basic Processes of Fabrication, viz., Casting, Forging, Welding, Machining, Pressing and Rolling, with Social and Economic Implications, William S. Knudsen.
Contribution of Machine Tool Builders to Mass Production in the Automotive Industry, by Fred W. Cederleaf.

Wednesday, May 19th—

9.00 a.m. The Aspects of Automotive Engineering which have been Applicable to Railroading, Ed. G. Budd.
The Economics of Power for Light-Weight Trains, Dr. Rupen Eksergian.

2.00 p.m. Welded Fabrication of Large Frames, by Everett Chapman.
Hydromatic Welding of Frames, C. L. Eksergian.
The Prevention of Surface Condenser Tube Failures, Robert, E. Dillon, George C. Eaton, and H. Peters.

2.00 p.m. (Cont.) The Condensation of Flowing Steam, John I. Yellott and C. Kenneth Holland.
Panel Discussion on Spreader Type Stokers, led by J. F. Barkley.
The Automobile Industry and Young Engineers, C. J. Freund.
Apparatus and Test Results on Dry Friction. Various Materials and Comparisons with Other Data, by W. E. Campbell.
Oil Film Thickness at Transition from Semi-Fluid to Viscous Lubrication, by G. B. Kayelitz and J. N. Kenyon.
Descriptive Lectures and Tours to Plymouth Assembly Line and Forge Shop of Chevrolet Gear and Axle Plant.
The Petroleum Industry in Michigan, by C. R. Miller.

8.00 p.m. The Decentralization of Industry, by W. J. Cameron.

Thursday, May 20th—

9.00 a.m. Modern Methods of Production and Quality Control of Sheets for Automobile Fabrication, T. F. Olt.
Proper Grain Structure Required for Deep Draw and Discussion of other Problems involved in Application of Wide Sheets, J. E. Angle and W. F. McGarrity.

2.00 p.m. Properties of Steel when Subjected to High-Velocity Loading, Col. Glen F. Jenks.
Economic Characteristics of Typical Business Enterprises, Walter Rautenstrauch.
A Study of the Lip Clearance on Twist Drills, Charles J. Starr.
The Grinding of Cemented Carbide Milling Cutters, Hans Ernst.
Report of Subcommittee on Metal Cutting Data on Reducing Production Costs by more Effective Use of Metal Cutting Tools, R. C. Deale.
The Pooling of Power Sources in a Large Industrial Centre, J. W. Parker and R. E. Greene.
Analysis and Tests on the Hydraulic Circuits of Surface Condensers, G. H. Van Hengel.
Notes on High Speed Diesel Engine Maintenance Practice in the Canadian National Railways, I. I. Sylvester.
New Urban Transportation Equipment and New Steam Railroad Equipment, H. L. Andrews.

6.30 p.m. Dinner Meeting.
President James H. Herron to speak on
1. Summary of Week's Programme and its implications.
2. Society Affairs.
Principal Speaker—Col. Willard T. Chevalier.
Followed by informal reception and dance.

Friday, May 21st—

9.00 a.m. Operating Experiences in the Steam and Power Department of the South's First Alkali Plant, G. P. Avery.
Formulas for Stresses in Bolted Flanged Connections, Everett O. Waters, D. B. Rossheim, D. B. Wesstrom, and F. S. G. Williams.
Railroad Streamlining, Dr. A. I. Lipetz.

An important feature of the meeting will be the sightseeing and technical inspection tours, arranged for both visiting engineers and ladies, a number of these being held each day throughout the meeting.

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VOLUME XX APRIL, 1937 No. 4

## The Plastics Industry

The discovery of a whole class of materials of a new type is an important event. That is what has happened within the last few years in the invention of the substances known as synthetic resins or resinoids. Many of these possess qualities which have enabled them to fill requirements for which no suitable material was previously available.

The synthetic resins belong to the class of plastics, substances which can be placed in moulds and then hardened in their finished form. Thirty years ago celluloid and vulcanite were the only plastics in common use. Their utility was limited, since after being moulded they soften at a moderate temperature and are subject to other disadvantages. In 1906, however, L. H. Baekcland discovered that on heating a mixture of phenol (carbolic acid) and formaldehyde (formalin) with a little ammonia, a substance was produced which resembled natural resin, and when warmed could be squeezed into a mould. He found that if the mould was then heated to about 300 degrees F. the material hardened, and thereafter did not soften at a reasonable temperature. The resulting material was hard, amber-like, an electrical insulator, had considerable mechanical strength, absorbed little or no moisture and was acid resistant. Under the name of bakelite it soon found wide acceptance, particularly in the electrical industry. Later it was found advantageous to mix the resinous mass with a filler, such as wood flour or paper pulp, and grind the mixture to a coarse powder, known as moulding powder. The powder, which becomes plastic under heat and pressure, is then pressed in the mould and is heated for a few minutes until the hardening reaction takes place. The use of a suitable filler led to a considerable saving in cost, and in many cases an increase in mechanical strength. If a long fibrous filler in woven or loose state is used, the finished product possesses much greater resistance to shock. In fact, laminated bakelite of this type can be used for gear wheels and for parts of electrical machinery or aeroplane equipment which require toughness and strength. Resinoids with a breaking strength of from 10,000 to 20,000 pounds per square inch are now available.

For some purposes, the brownish colour of bakelite was found to be a disadvantage. About 1920 it was discovered that urea, a substance formed synthetically from carbon dioxide and ammonia, would combine with formaldehyde to give a colourless, translucent resinoid which can be dyed or filled with coloured pigment. Some recent plastics are so clear and transparent that they can be used as a substitute for glass. Others are valuable as bases for paints and varnishes, for which purpose their superior resistance to weather enables them to replace natural resins to a considerable extent, thus leading to marked improvement in the protective power and durability of paints and varnishes for both wood and metal surfaces.

In addition to the phenolic and urea types of plastics there are others of more recent discovery. The alkyd resinoid, formed by chemical action between glycerine and phthalic acid, for instance, is a water-white material which cuts like horn, and can be used as a substitute for shellac in electrical insulation. Still other classes are produced from acetylene or from acetone, the latter being the basis of the material which shows most promise as a light-weight substitute for glass for aeroplane screens and windows. In fact, patents for new types of synthetic resins are constantly appearing.

When a resinoid is hardened by heat, interesting molecular changes occur, due to a process which chemists call polymerization. It is now known that the linking of atoms into rings and chains by interchanging their chemical bonds may produce larger units less easily moved by the atomic vibrations which we call heat. This happens when bakelite is heated to about 300 degrees F., when the short chains of perhaps a half dozen minute links of phenol and formaldehyde join each other and form comparatively long chains of molecules. The hardened bakelite is thus an irregular tangle of minute thread-like chains of molecules, which further heat will not disentangle, although at a much higher temperature the material will ultimately char and decompose. Actually, vegetable and animal fibres are all composed of chain-molecules of this type, held together by electrical attraction.

The development of the plastics industry has been favoured by the cheapness of its raw materials. Fortunately coal, air and water are plentiful. For example, nitrogen, from air, and hydrogen, from water, are made to combine under high pressure to form ammonia, which in turn will react with carbon dioxide, also under high pressure, to form urea. Formaldehyde is made from air and methyl alcohol, which itself is made from carbon monoxide and hydrogen, both these gases being produced by blowing steam over white hot coke. The resulting urea and formaldehyde give us one important class of plastics.

It seems unlikely that plastics will replace metals for most engineering purposes, or that research will be able to produce resinoids approaching steel in tensile strength, hardness or resistance to wear, but they are replacing metals for many articles not requiring great strength or hardness, particularly for household use. They are now indispensable in the electrical industry, where they supply a long felt want. They will probably replace pottery for many purposes. A list of their present uses would fill pages of this Journal.

The plastics industry has now passed through the troubles of infancy, and has taken its place as an important source of supply for electrical, aircraft and automobile manufacture, and for innumerable personal and domestic requirements. It forms an effective auxiliary in many lines of manufacture and increases the demand for a wide range of basic products. The creation of an entirely new industry of such wide scope is likely to have many favourable economic results. There is a recent suggestion, for example, that unemployment conditions, which are still so difficult in certain "depressed areas" in Britain, could be materially improved by the local development of factories for plastic products.

## Semicentennial Committee

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### TRANSPORTATION

The Canadian Passenger Association has granted reduced fares—namely, one and one third plus 25 cents, for the Semicentennial, good going June 11th to June 17th, return limit 30 days. All members will be supplied with the necessary identification certificate very shortly.

More complete particulars will appear in our next announcement.

### OTTAWA MEETING

Committees under the general chairmanship of Mr. A. K. Hay, A.M.E.I.C., are actively engaged in preparation for the Semicentennial activities on Friday, June 18th. A luncheon and dinner dance are being arranged, at both of which there will be guest speakers of prominence.

In addition, arrangements are being made for visits to such notable engineering works as the power plants of the Gatineau Power Company, the Gatineau Mill of the Canadian International Paper Company, and the laboratories of the National Research Council.

### VISITORS

The Society of Naval Architects and Marine Engineers (New York) is being represented at the Semicentennial by seven members of its Council, including Mr. H. Gerrish Smith, Vice-President and Secretary-Treasurer, and a number of notables in the marine engineering world.

### TECHNICAL PAPERS

The papers for presentation at the Semicentennial, and also those dealing with the historical review of engineering in Canada, for the Semicentennial issue of the Journal are now rolling into headquarters. In due course they will be made available in preprint form.

The Symposium on the burning of Canadian coals by eleven authors is going to be a notable contribution to the meeting, and to the literature of engineering.

### PLENARY MEETING OF COUNCIL

A plenary meeting of the Council of The Institute has been called for Monday, June 14th.

## OBITUARIES

### Frederick William Angel, A.M.E.I.C.

It is with deep regret that we place on record the death at St. John's, Newfoundland, on March 4th, 1937, of Frederick William Angel, A.M.E.I.C.

Mr. Angel was born at St. John's on December 15th, 1874, and graduated in engineering with first class honours from McGill University in 1898. He returned to St. John's as mechanical draughtsman with the Reid Newfoundland Company, and in 1899 became acting superintendent of the locomotive shops of the same company. In 1900 Mr. Angel joined the staff of the Dominion Iron and Steel Company, and was located at Bell island until 1902. He subsequently became secretary and manager of the Angel Engineering and Supply Company, and within ten years became one of Newfoundland's leading consulting engineers. At the time of his death Mr. Angel was president of William Heap and Company, and William Noseworthy Limited; vice-president and managing director of the St. John's Nail Manufacturing Company; managing director of the Bell Island Transportation Company; secretary of the Consolidated Foundry Limited, and a director of the Newfoundland Power and Paper Utilities Corporation.

Mr. Angel joined The Institute (then the Canadian Society of Civil Engineers) as an Associate Member on October 12th, 1905.

### Joseph William Heckman, A.M.E.I.C.

It is with regret that we place on record the death at Montreal on March 20th, 1937, of Joseph William Heckman, A.M.E.I.C., a member of The Institute of many years standing.

Mr. Heckman was born in October 1854, and was a graduate of the University of King's College, Nova Scotia, from which institution he received the degree of Bachelor of Engineering in 1876. He was subsequently engaged in the location and construction of railways, and from 1880 until 1887 he was on the staff of the Federal Department of Railways and Canals. In 1888 Mr. Heckman entered the service of the Canadian Pacific Railway Company, as assistant engineer. In 1898 he was appointed photographer in the engineering department, and in 1902 he became inspector, and was located at Fort William, Ontario. In 1903 Mr. Heckman was transferred back to Montreal, and was engaged in various capacities until April 1921 when he retired from the service.

Mr. Heckman joined The Institute (then the Canadian Society of Civil Engineers) as an Associate Member on February 24th, 1887, and was made a Life Member on May 27th, 1924.

### Alphonse Lafleche, M.E.I.C

We regret to have to record the death at Montreal on March 8th, 1937, of Alphonse Lafleche, M.E.I.C.

Mr. Lafleche was born at St. Martin, Laval County, Quebec, on December 5th, 1884, and graduated from the Ecole Polytechnique, Montreal, in 1909, with the degree of C.E. After two years of general engineering work, he entered the service of the Dominion Department of Marine as assistant engineer in 1911. In 1917 Mr. Lafleche became senior assistant engineer, and in 1929 was appointed assistant chief engineer, the River St. Lawrence Ship Channel, which office he held until his death. Mr. Lafleche's knowledge of the St. Lawrence river from Montreal to the sea was wide and thorough, and this was recognized by the Federal Government in 1934 when he was appointed a member of the Interdepartmental Water Levels Board, appointed to study and report on the cause of recurring low water levels in the St. Lawrence and at Montreal.

Mr. Lafleche became a Student of The Institute on January 14th, 1909, an Associate Member on June 27th, 1916, and a full Member on May 21st, 1935.

### Thomas Taylor, M.E.I.C.

Members of The Institute will learn with much regret of the death at Toronto, Ontario, on December 21st, 1936, of Thomas Taylor, M.E.I.C.

Mr. Taylor was born at Cheltenham, Ontario, on January 1st, 1876, and graduated from the School of Practical Science, University of Toronto, in 1902. Following graduation Mr. Taylor was employed in detailing and checking structural work with various construction companies in the United States and Canada, and from 1909 until 1911 worked with the Canada Foundry Company, designing and estimating steelwork for buildings. In 1912 Mr. Taylor entered the service of the Department of Works of the City of Toronto as assistant to the engineer of railways and bridges, and was engaged on bridge maintenance and construction. He designed and superintended the construction of the Bloor Street viaduct, and later was appointed engineer of railways and bridges for the city. During his service in this capacity, Mr. Taylor supervised the designing of the St. Clair Avenue East bridge, the North Glen Road bridge, and the Eastern Avenue bridge. He held the appointment up to the time of his death.

Mr. Taylor became a Member of The Institute on April 18th, 1916, and took an active interest in the affairs of the Toronto Branch, having been chairman of the Branch in 1929.

### Samuel Fraser Workman, M.E.I.C.

Deep regret is expressed in placing on record the accidental death at Goldstream, B.C., on March 19th, 1937, of Samuel Fraser Workman, M.E.I.C.

Mr. Workman was born at Montreal, Que., on November 2nd, 1884, and from 1906 until 1910 was chainman and transitman with the Canadian Northern Railway. In 1910 he joined the staff of the Canadian Northern Pacific Railway as transitman; from 1912 until 1914 he was resident engineer for the railway in charge of construction on Vancouver Island. Proceeding overseas with the Canadian Railways Troops, Mr. Workman was lieutenant in charge of construction and operation of light railways, with the Canadian Corps. From November 1916 until February 1919 he was officer commanding the Light Railway Company with the Canadian Expeditionary Force in France, with the rank of Major. Mr. Workman was twice mentioned in despatches and was awarded the Military Cross.

Returning to Canada in 1919, Mr. Workman became resident engineer in charge of construction of the Okanagan Branch of the Canadian National Railways. In 1922 he was with the Black Mountain Irrigation District at Rutland, B.C., and in 1923 he was attached to the Department of Public Works of the Province of British Columbia. In 1930 Mr. Workman was superintendent with the Fraser Valley Tie and Timber Company at Kamloops, B.C., and at the time of his death he was road engineer for the Associated Engineering Company.

Mr. Workman became an Associate Member of The Engineering Institute of Canada on March 23rd, 1920.

## PERSONALS

A. Clairmont, S.E.I.C., who has been connected with the Singer Sewing Machine Company at St. Johns, Que., has been appointed plant engineer for the same company at Thurso, Que. Mr. Clairmont graduated from the Ecole Polytechnique in 1936, with the degree of B.A.Sc.

O. N. Mann, S.E.I.C., is now on the staff of the Eagle Pencil Company at Drummondville, Que. Mr. Mann, who graduated from the Nova Scotia Technical College in 1935 with the degree of B.Sc., was formerly with the Imperial Oil Limited, at Halifax, N.S.

Charles L. Bates, M.E.I.C., has recently been appointed chief engineer of the Pacific Great Eastern Railway, Vancouver, B.C. Mr. Bates graduated from the Massachusetts Institute of Technology in 1903 with the degree of B.Sc. and in 1904 joined the Canadian Pacific Railway Company as resident engineer on construction. He also served in that organization as assistant division engineer in the construction department and in the engineering department on maintenance of way until 1915. From 1915 until 1920 Mr.

Charles L. Bates, M.E.I.C.

Bates was engaged in private municipal engineering practice. In 1921, after being on the construction of Pier B.C. in Vancouver for the Canadian Pacific Railway, he joined the Northwest Dredging Company of Vancouver, as chief engineer and superintendent, remaining with that company until 1926. Since 1927 Mr. Bates has been with the Pacific Great Eastern Railway as maintenance of way engineer.

M. F. Cossitt, A.M.E.I.C., has been appointed city engineer of the City of Sydney, N.S. Mr. Cossitt, who has been engaged in private practice in Sydney, was at one time with the International Paper Company Limited, at Corner Brook, Nfld.

A. J. E. Smith, S.E.I.C., who graduated from the University of Toronto in 1935 with the degree of B.A.Sc., and is sales engineer with Canadian Allis-Chalmers Limited, has been transferred by that company from Toronto to Winnipeg, Man.

B. P. Rapley, A.M.E.I.C., has returned to Talara, Peru, as chief engineer for the International Petroleum Company there. Mr. Rapley was acting chief engineer for the company at Talara in 1935, but during 1936 was with the Imperial Oil Company at Sarnia, Ontario.

G. H. E. Dennison, A.M.E.I.C., has recently returned from a trip to Europe, where he visited Great Britain, Norway, Sweden, Finland and Russia, spending about two months in a number of paper mills in the U.S.S.R. Mr. Dennison, who is with the Canadian Carborundum Company Limited, at Niagara Falls, Ontario, has made a number of similar trips to Europe during the past few years, making a special study of groundwood and grinding problems. Following graduation from the Royal Military College in 1920, Mr. Dennison was connected with the Lake Superior Paper Company, and the Spanish River Pulp and Paper Mills Limited, at Sault Ste. Marie, Ontario. From 1928 until 1930 he was engineer at the Sault Ste. Marie mill of the Abitibi Power and Paper Company, and from 1931 until 1934 was with the Algoma Steel Corporation. In 1934 Mr. Dennison accepted the position with the Canadian Carborundum Company which he now holds.

A. Duperron, M.E.I.C., formerly chief engineer of the Montreal Tramways Commission, has been appointed chief engineer of the Montreal Tramways Company. Mr. Duperron is a graduate of the Ecole Polytechnique, Montreal, from which he received the degree of B.A.Sc. in 1911. During his college course he was engaged on various survey works, and immediately following graduation he was associated with Mr. E. Laignon on hydro-electric and building construction. In September of the same year he was engaged on railway location with the Central Railway of Canada between Hawkesbury and Ottawa, and in January 1912 Mr. Duperron accepted a position with W. I. Bishop, M.E.I.C., on hydro-electric surveys on the St. Francis river and on construction work at Drummondville, Que. From September 1912 until May 1913 he was employed in the office of the construction department of the Canadian Pacific Railway at Montreal, subsequently being transferred to the bridge department on the design and preparation of bridge plans. In August 1915 he joined the staff of the Quebec Streams Commission, first as chief of a survey party in the Lake St. John district, and later in charge of construction of the superstructure of a bridge over the Sauvage river in connection with the Lake St. Francis reservoir. Following this he was on the staff of the Commission at Montreal. In 1927 Mr. Duperron was appointed chief engineer of the Montreal Tramways Commission.

Mr. Duperron takes an active interest in Institute affairs, having been chairman of the Montreal Branch in 1931, and at the present time represents that Branch on the Council.

E. C. Kirkpatrick, M.E.I.C., is now works manager of the Montreal Division of the Steel Company of Canada, Limited. Mr. Kirkpatrick has been connected with that company since graduating from McGill University in 1906 with the degree of B.Sc., first as a draughtsman, later as superintendent of construction, and then as mechanical engineer, which position he has held for a number of years.

**F. H. Kester, M.E.I.C.**

F. H. Kester, M.E.I.C., has been elected President of the Canadian Bridge Company Limited, Walkerville, Ontario. With this office he combines the general managership. Mr. Kester, who studied structural and mechanical engineering at the University of Wisconsin, joined the staff of the Canadian Bridge Company in 1907 as draughtsman, becoming successively, assistant engineer from 1912 until 1919, contracting engineer from 1919 until 1927, and vice-president and director from 1927 until the present time.

R. A. Spencer, M.E.I.C., was recently appointed vice-president of the Canadian Bridge Company Limited, Walkerville, Ont. Mr. Spencer graduated from the University of Vermont in 1908 with the degree of B.Sc. and in 1909 was field superintendent for the Peterson Lake Mining Company, located at the Nova Scotia Mining Company, Cobalt, Ontario. During the years 1910-1912 he was with

**R. A. Spencer, M.E.I.C.**

the Nova Scotia Mining Company as cost keeper and assistant to the superintendent during the construction of cyanide mills. In 1912 Mr. Spencer joined the staff of the Canadian Bridge Company Limited as a draughtsman, and continued with that company in various capacities until 1927 when he was appointed contracting engineer, which position he has held up to the present time.

Colonel J. L. H. Bogart, R.C.E., D.S.O., A.M.E.I.C., has been appointed Officer Commanding Military District 13, at Calgary, Alta. Colonel Bogart, who was formerly stationed at Petawawa, Ontario, was at one time Director of Engineer Services, Department of National Defence, Ottawa, Ont.

V. W. Dick, A.M.E.I.C., is now in the engineering office of the Winnipeg Electric Company in Winnipeg, as junior engineer. Mr. Dick graduated from the University of Manitoba in 1921 with the degree of B.Sc., and subsequently took the students course of the Canadian Westinghouse Company Limited. From 1923 until 1926 he was with the same company as sales engineer, and from 1926 until 1929 he was draughtsman with the Manitoba Power Company Limited. In 1929 Mr. Dick became electrical designer for the Northwestern Power Company Limited, and remained in that position until 1931 when he was electrical inspector for the Northern Power Company at Seven Sisters, Man. He was later operator for the Northwestern Power Company Limited.

A. Holland, A.M.E.I.C., has been appointed as Colonial Engineer and Surveyor General, with the Public Works Department, Roseau, Dominica, Leeward Islands. Mr. Holland's previous colonial service was as an executive engineer, with the Public Works Department, Gold Coast Colony, West Africa. More recently Mr. Holland has been located in Chester, England.

S. McCune, Jr. E.I.C., is now on the staff of the General Engineering Company (Canada) Limited, and is at present engaged in the design of the mill extension of the Aldermac Copper Corporation at Arntfield, Que. Mr. McCune, who graduated from the University of Illinois in 1930 with the degree of B.Sc., was formerly with the Ontario Department of Northern Development at Sudbury, Ontario.

## Elections and Transfers

At the meeting of Council held on March 23rd, 1937, the following elections and transfers were effected:

*Members*

ANVIK, Herlaug, M.E., (Kristiania Tech. Coll.), efficiency engr., Canadian International Paper Co. Ltd., Temiskaming, Que.

WATSON, Alexander, (Robt. Gordon's Coll.), chief engr., marine dept., Canadian Vickers Ltd., Montreal, Que.

*Associate Member*

FRY, Frederick George, B.A.Sc., (Univ. of Toronto), asst. divnl. engr., Shell Oil Co. of Canada Ltd., London, Ont.

SHAW, William Ulric, B.A.Sc., (Univ. of Toronto), asst. engr., Fairchild Aircraft Ltd., Longueuil, Que.

WILSON, William Bowman, B.Sc., (McGill Univ.), res. engr., R.C.A.F. Station, Trenton, Ont.

*Juniors*

ASKWITH, Winston M., B.Eng., (McGill Univ.), instr'man. and asst. engr., Federal District Commission, Ottawa, Ont.

BRADFORD, George Allen McClean, B.Sc., (Univ. of Sask.), dftsman., Imperial Oil, Ltd., Sarnia, Ont.

DORAIS, Gabriel, B.A.Sc., C.E., (Ecole Polytech., Montreal), with E. Gohier, M.E.I.C., consltg. engr., Montreal, Que.

ENGLER, Charles Roy, B.Sc., (Queen's Univ.), dftsman., J. H. Connor & Son Ltd., Ottawa, Ont.

FOTHERINGHAM, William Webster, B.Sc., (Univ. of Man.), engr., Standard Iron Works Ltd., Edmonton, Alta.

GRAHAM, George, B.Sc., (Univ. of Sask.), bureau of economic geology, Dept. of Mines, Ottawa, Ont.

SOMMERVILLE, Donald Barton, B.A.Sc., (Univ. of Toronto), struct'l. engr., Canadian Comstock Company, Toronto, Ont.

STEIN, Marcus, B.Eng., (McGill Univ.), 3849 St. Urbain St., Montreal, Que.

*Affiliate*

CROSSE, Claude St. Cyr, plant operation and mtce., Hydro-Electric Power Commission of Ontario, Niagara Falls South, Ont.

*Transferred from the class of Associate Member to that of Member*

DINGWALL, Robert Macfarlane, A.R.T.C. (Mech.), (Royal Technical College), mgr. and director, Standard Iron Works Ltd., Edmonton, Alta.

KEAN, David Jacques, (Univ. of Toronto), county engr. and road supt., P..O. Box 579, Whitby, Ont.

TALMAN, Stephen Goldwyer, dftsman., dept. of works, water distribution section, City of Toronto, Toronto, Ont.

TURNER, Earle O., S.B. (Civil), (Mass. Inst. Tech.), professor of civil engrg., University of New Brunswick, Fredericton, N.B.

*Transferred from the class of Junior to that of Associate Member*

ELLIOT, Donald George, B.Sc., (Univ. of Edinburgh), asst. mill engr., Anglo-Newfoundland Development Co. Ltd., Grand Falls, Nfld.

GAUVIN, Herve Alfred, B.Sc. (Civil), (McGill Univ.), divn. engr., Dept. of Highways, L'Assomption, Que.

WARDLEWORTH, Theophilus Hatton, B.Sc., (McGill Univ.), designer, Aerocrete Construction Co. Ltd., Montreal, Que.

*Transferred from the class of Student to that of Associate Member*

CAMERON, John, B.Sc., (N.S. Tech. Coll.), asst. engr., Can. Gen. Elec. Co. Ltd., Peterborough, Ont.

DYMENT, John Talbot, B.A.Sc., (Univ. of Toronto), asst. engr., aeronautical engrg. divn., Dept. of National Defence, Ottawa, Ont.

EMERY, Donald Joseph, B.A.Sc., (Univ. of B.C.), asst. engr., Can. Gen. Elec. Co. Ltd., Peterborough, Ont.

*Transferred from the class of Student to that of Junior*

DAVIDSON, Arthur Campbell, B.Sc. (C.E. and E.E.), (Univ. of Man.), 1732-11th St. West, Calgary. Alta.

DOUGLAS, Arnold Howard, B.Eng. (Civil), (Univ. of Sask.), junior engr., Dept. Public Works, Canada, Langham, Sask.

TOLLINGTON, Gordon C., B.Sc., (Univ. of Alta.), induction motor engrg. dept., Can. Gen. Elec. Co. Ltd., Peterborough, Ont.

*Students Admitted*

ANDRE, Kenneth Bailey, (Queen's Univ.), 324 Johnson St, Kingston, Ont.

BAKER, William Gordon, (McGill Univ.), 821 McEachran Ave., Outremont, Que.

BECKER, Sidney John, (McGill Univ.), 282 Villeneuve St. W., Montreal, Que.

BOONE, Harold Percival, (Univ. of N.B.), 470 Charlotte St., Fredericton, N.B.

BOURNE, James Douglas, (McGill Univ.), 32 Holton Ave., Westmount, Que.

CARSON, Robert John, (Grad. R.M.C.), (Queen's Univ.), 72 Barrie St., Kingston, Ont.

DICK, William Arthur, (McGill Univ.), 1512, St. Mark St., Montreal, Que.

DOUCETT, Rolphe Leigh, B.Eng., (N.S. Tech. Coll.), Shediac, N.B.

DRAKE, Thomas Stuart, (McGill Univ.), 3298 Cedar Ave., Westmount, Que.

DUCHASTEL, Pierre Arthur, (McGill Univ.), 640 Dunlop Ave., Outremont, Que.

EDWARDS, Milton Chalmers, (Univ. of Alta.), P.O. Box 193, University of Alberta, Edmonton, Alta.

ELFORD, Wesley Fred, (Univ. of Alta.), Foremost, Alta.

EXELROD, Bert, (McGill Univ.), 260 Laurier Ave. W., Montreal, Que.

FISH, Abe, (McGill Univ.), 2012 Ontario St. East, Montreal, Que.

HALL, Gordon Hudson, (R.M.C.), 88 London St., Peterborough, Ont.

HERTEL, Alfred Frederick, B.Sc., (Queen's Univ.), 155 Central Ave., London Ont.

HIBBARD, Ashley Gardner, (McGill Univ.), 4712 Western Ave., Westmount, Que.

HORWOOD, William Osmund, (McGill Univ.), 5806 Notre Dame de Grace Ave., Montreal, Que.

HURST, Charles Kenneth, (Univ. of Alta.), St. Stephen's College, Edmonton, Alta.

KENNEDY, Harold E., (Queen's Univ.), 48 Highview Crescent, Toronto, Ont.

KIRKPATRICK, Robert Evans, (McGill Univ.), 47 Ainslie Rd., Montreal West, Que.

KOSNAR, Vincent George, (McGill Univ.), 3591 Jeanne Mance St., Montreal, Que.

LANGSTON, John Francis, (Univ. of Alta.), Edmonton, Alta.

LEGER, Joseph Arthur Kennedy, (Univ. of N.B.), P.O. Box 245, Newcastle, N.B.

LEWIS, Crompton Emerson, B.A.Sc., (Univ. of Toronto), 334 Reid St., Peterborough, Ont.

LOISELLE, Harold John, (McGill Univ.), 65 Duverger Ave., Outremont, Que.

MacGIBBON, James Alexander, (McGill Univ.), 3723 Jeanne Mance St., Montreal, Que.

MARSHALL, Welsford Allen, (Queen's Univ.), 184 University Ave., Kingston, Ont.

McLEAN, Murray Douglas, (McGill Univ.), 2325 St. Luke St., Montreal, Que.

NOWLAN, Brete Cassius, (McGill Univ.), 5510 Queen Mary Rd., Montreal, Que.

PARKER, Edmund Norval, (McGill Univ.), 505 Argyle Ave., Westmount, Que.

PARSONS, Ronald Albert, (Univ. of Alta.), 8909-112th St., Edmonton, Alta.

PEACOCK, Robert Frederick, (Univ. of N.B.), Lady Beaverbrook Residence, University of New Brunswick, Fredericton, N.B.

POOLE, John Edward, (Univ. of Alta.), 11716-100th Ave., Edmonton, Alta.

SCHWARTZ, Harry H., (McGill Univ.), 5230 Clarke St., Montreal, Que.

SHECTOR, Lindley, (McGill Univ.), 2241 Maplewood Ave., Montreal, Que.

SPRINGFORD, William R. H., (Univ. of N.B.), 29 Allen St., Fredericton, N.B.

THOMPSON, Arthur McCall, (Univ. of Alta.), P.O. Box 194, University of Alberta, Edmonton, Alta.

WILSON, Murray Edgar, (Univ. of N.B.), 34 Enterprise St. Moncton, N.B.

## Erratum

In publishing Professor G. Vibert Douglas' paper entitled "Some Features of Mining Geology" in the March, 1937, issue of The Engineering Journal, the formula shown at the foot of the right-hand column on page 118 should have read as follows:—

$$\text{Present Worth} = \frac{A}{\dfrac{0.04}{(1+0.04)^n - 1} + 0.10}$$

## CORRESPONDENCE

The Editor,
The Engineering Journal,
Montreal.
Dear Sir:—

I have just recently returned from Europe, and thought that you might be interested to hear something of my trip. I visited Great Britain, Norway, Sweden, Finland and Russia, spending about two months in a number of paper mills in the U.S.S.R. The Russian cities, particularly Moscow, reflect the increasing prosperity of the country, and I found the appearance of the streets, the shops and the dress of the people themselves considerably improved in the last year. The new constitution adopted last November guarantees citizens peaceful possession of personal belongings, and jewels, furs, etc. long concealed appear in public once more. Money appears plentiful in certain quarters, particularly among writers, musicians and artists attached to the theatre, and there is plenty of feasting, drinking and dancing in the Moscow restaurants, although the prices are still exorbitant. Whether this last phase of existence will be lasting or not remains to be seen. Russia has passed through many phases since the revolution.

Industrial development continues in Russia to absorb most of the national income. Capital construction goes about 75 per cent into new plants, equipment and transport; 25 per cent into dwellings, schools, theatres, etc. The output of industry has been considerably increased by the adoption of piece-work as a basis of payment, known in Russia as the Stahkanov movement. The unit output per worker is still however only a fraction of that obtained here and their living conditions vastly inferior to that of workmen in Canada.

Although there are said to be 10,000 newspapers in Russia, only two of them, Pravda and Izvestia, are widely read or widely circulated within the country. The circulation of these papers has to be restrained due to the scarcity of paper, for although there are many newsprint mills in Russia, their output is used for a wide variety of purposes for which finer papers are used here.

The output of paper in Russia this year will be increased by nine new machines of their own manufacture, and is expected to approximate one million tons. The new machines are similar to the Bagley-Sewell machines operating at Balahkna, but incorporate features of other makes and original designs of the Russian engineers.

Everything considered, the paper industry in Russia has lagged in development behind other industries, but steps are now being taken to bring it up in line. Interest in machine improvements, in pre-heating cooking acid for digesters and in vitrified abrasives for pulp grinding is strongly evidenced on all sides.

In Norway, Sweden and Finland, rapid progress is being made towards industrial recovery. Many Norwegian paper mills have been shut down or operating at reduced output, but now with rising prices an active programme of rehabilitation is going forward while Finland's rapidly growing export trade has already made its influence felt on world markets.

Yours very truly,
Geo. H. Dennison, A.M.E.I.C.

Niagara Falls, Ontario,
March 21st, 1937.

## BULLETINS

*Construction Machinery.*—A 20-page booklet received from the London Concrete Machinery Co. Ltd., London, Ontario, contains particulars of their concrete mixers and general line of construction machinery, including hoses, pumps, engines, etc.

*Grinding Machine.*—Brown and Sharpe Mfg. Company, Providence, R.I., have issued an 8-page leaflet describing their new No. 10 cutter and tool and grinding machine. This is a new design and the complete equipment can cover a wide variety of grinding. Particulars of attachments are included.

*Proportioning Equipment.*—A 24-page catalogue issued by D. W. Haering and Company, Inc., Chicago, Ill., describes the operation and application of proportioning equipment, and explains the use of the Haering fluid piston principle, including detailed descriptions of the new model twin feeders. The use of pitot tubes, fluid pistons and proportioning of various chemicals is discussed in detail.

*Water Meter.*—The Worthington-Gamon Meter Company, Harrison, N.J., has issued an 8-page bulletin describing their Watch Dog disc water meter of heavy duty type, which comes in 3- and 4-inch sizes, having respectively a safe maximum delivery capacity of 315 and 500 gallons p.m.

*Milling Machinery.*—An 8-page folder received from Brown and Sharpe Mfg. Co., Providence, R.I., contains a description of their No. 22 plain milling machine, for which they claim quick setups, unusual rigidity, etc.

*Turret Lathes.*—A 4-page leaflet received from The Bullard Company, Bridgeport, Conn., contains particulars of their vertical turret lathes, manufactured in 24, 36, 42, 54 and 64 inch sizes.

*Diesel Engines.*—The English Electric Company of Canada Limited, St. Catharines, Ont., in a 22-page bulletin, give specifications of design and construction of their 2-stroke cycle engines, of medium speed, in sizes of 150 to 1,000 B.h.p.

## Recent Additions to the Library

### Proceedings, Transactions, etc.

American Society of Mechanical Engineers: Transactions 1936, vol. 58.

American Society for Testing Materials: Proceedings of the 39th Annual Meeting, 1936. Volume 36.

The Society of Engineers Inc.: Transactions, 1936.

American Institute of Consulting Engineers: Proceedings of the Annual Meeting, 1937.

### Reports, etc.

*American Society of Mechanical Engineers:* List of Members, 1937.

*Dominion Bureau of Statistics:* Report of the Construction Industry in Canada, 1935.

*Canada, Dept. of Labour:* Wages and Hours of Labour in Canada, 1929, 1935 and 1936.

*Canada, Dept. of Labour:* Prices in Canada and other Countries, 1936.

*Canada, Dept. of Railways and Canals:* The Welland Ship Canal, 1913-1932. Reprint of articles by Major P. J. Cowan, M.B.E., M.Inst.C.E., M.I.Mech.E., appearing in *Engineering.* (Presented through the courtesy of D. A. McLachlan, M.E.I.C)

*Canada, National Research Council:* Soil Temperatures in Canada, by R. Ruedy.

*Canada, Forest Service:* Wood and Charcoal as Motor Fuels.

*Canada, Dept. of Mines:* Report for the year ending March 31st, 1936.

*Institution of Civil Engineers:* List of Members, January 1937.

*Canada, Dept. of Mines and Resources, Bureau of Mines:* Fuel Briquetting.

### Technical Books, etc.

Whitaker's Almanack, 1937.

Road Curves for Safe Modern Traffic, F. G. Royal-Dawson (*E. and F. N. Spon, London*).

De l'Anglais au Français en Electrotechnique, by R. Dupuis (*Presented by the author*).

Rayon and Synthetic Yarn Handbook, by Dr. E. W. K. Schwarz and H. R. Mauersberger (*Rayon Publishing Corp., New York*).

Rail, Road and River, W. W. Swanson (*Macmillan Company of Canada Limited, Toronto*).

## BOOK REVIEW

### Rayon and Synthetic Yarn Handbook

*By Dr. E. W. K. Schwarz and Herbert R. Mauersberger. Rayon Publishing Corporation, New York. 1936. 5¼ by 7¾ inches. 558 pages. 230 illustrations, tables, charts. Second enlarged edition. $4.50. Cloth.*

This handbook, which is described as a practical reference book for the producer, manufacturer, processor, distributor, dry-cleaner, launderer, economist and student, contains twenty chapters, the first of which deals with the historical background of the European and the American rayon industry. The economic and statistical background of the industry, and raw materials and their preparation are dealt with in the opening chapters. Chapter four includes a description of the following four yarn manufacturing processes: viscose, cellulose acetate, the cuprammonium process, and the nitro-cellulose process. The winding, soaking and throwing, warping and warp sizing, and weaving of rayon goods, are described in the ensuing chapters, as is the construction of commercial grey goods and the manufacture of rayon knit goods. The next chapters deal with the dyeing of rayon yarns and goods, the printing of rayon and synthetic fabrics, and dry finishing and special processes. Chapters dealing with physical and chemical tests and identification follow, and the dry cleaning of rayon and acetate materials, the laundering of washable synthetic fabrics have not been neglected.

A bibliography of American and foreign literature is included.

**Ballot for the Amendments to the By-laws**

Corporate Members will please note that the

**Ballot Closes at Noon on April 20th, 1937.**

# Developments in the Art of Surveying

**Extracts from an address before the Canadian Institute of Surveying on February 3rd, 1937, by Major-General A. G. L. McNaughton, C.M.G., D.S.O., LL.D., M.E.I.C. President, the National Research Council, Ottawa.**

Eleven years ago I had the privilege of addressing your organization, then the Association of Dominion Land Surveyors.

In the interim, it has been my fortune to hold a position from which I could watch the many developments in the art of survey in Canada, particularly those which have come about in the Geographical Section.

During this period, the most notable advance has been the application of air photographs to survey purposes and their development from the rudimentary uses in the Great War until today they form an essential component in the mechanism of map-making in all its various divisions. From elementary qualitative results, today, the air photograph is depended upon for precise measurements, both in plan and in elevation, and for much of the topographical and other information which requires to be depicted on the modern map, and which otherwise could only be acquired by the painful and slow process of traversing the ground on foot.

Canada was in a specially favourable position to take advantage of the air photograph for survey. We had available all the wealth of practical experience which had come from the work of Bridgland and Wheeler in the photogrammetric survey of the mountain areas of British Columbia and Alberta; we had the experience which our survey officers brought back from Europe where, under the strong incentive of war, developments had taken place which, otherwise, might have required decades; and, perhaps most importantly, we had in front of us an urgent task to make available maps of vast areas which could not be met by any of the methods previously available. Further, much of the area to be mapped was interspersed with large lakes which provided automatically a horizontal plane of reference and thus enabled the use of a simplification of the oblique perspective method appropriate to the then state of the art.

It was recognized from the earliest days of the formation of the Department of National Defence that the pilots of the Air Force would need extensive training and practice in air photography, as this is one of their important duties in war, and it was the preoccupation of all concerned to see that this work served also a useful economic purpose.

Much the same is true of the maps made by the Geographical Section. The personnel had to be trained and there is no training so useful as a job of practical work.

On the formation of the Department of National Defence in 1923, one of the first things done was to establish an Interdepartmental Committee so that requests for air photos could be co-ordinated and the best possible use made of the limited flying time available from the R.C.A.F.

In 1926, reorganization and consolidation of survey services were very much under discussion. We have had to wait for more than ten years for this objective to be realized, but it has been realized at last and I join in sincere congratulations to the Hon. T. A. Crerar, and to his Deputy, Dr. Camsell, who have now brought about this much desired consummation. All of us who are interested in the progress of survey in Canada can look forward to a period of great progress.

We are now in a position, for the first time, to really plan our mapping and charting programmes on a broad and comprehensive basis, and the organization which has been set up makes possible a concentration of effort on those sections of the work which are, for the time being, of predominant importance.

The Interdepartmental Committee on Air Photographs was reorganized in 1929 to provide wider representation of the services concerned. In 1933 the whole situation was re-examined and as a result it seemed that requirements in connection with air photographs could best be met by dividing the task into several parts: first, the control of actual photographic operations was entrusted to a reorganized Interdepartmental Committee under the chairmanship of Dr. Camsell; second, the investigation of new methods of turning the advantages of the air photograph to account was remitted to a Survey Research Committee organized under the Research Council; and, third, the general responsibility for finding new and advantageous uses for air photographs, not only for mapping but for other purposes as well, was entrusted to a separate division of the Topographical Surveys under the charge of Mr. A. M. Narraway. Mr. Narraway became the secretary both of Dr. Camsell's committee and of the Research Council committee, thus providing a very necessary link between the several organizations concerned.

As regards Dr. Camsell's committee, and its predecessor, in the intervening years since 1922, 700,000 photographs, covering nearly as many square miles of our territory, have been taken by the R.C.A.F., or acquired from other sources, and these photographs have been classified and indexed as a national collection available for any purpose required.

Today, I am to speak primarily from the point of view of the National Research Council, and, particularly, of our Committee on Survey Research, and to endeavour to give you some account of the facilities which we can place at your disposal to assist you in the development of new and still further improved methods so that the maps required to plan and execute the development of our vast territories may be made available at less cost, in less time, and to the end that they will possess that high degree of precision in the representation of relevant detail and topographical features which are now such essential characteristics if they are to serve a useful purpose.

The Committee on Survey Research is now in process of reorganization to fit in with the consolidation which has taken place in the Department of Mines and Resources. At present the committee has sections devoted to:

- Infra-red and Colour Photography;
- Contouring from Air Photographs and Instruments for Plotting;
- Photographic Aircraft;
- Aerial Camera Auxiliaries and Testing of Film and Photographic Material.

The membership of these subcommittees comprises not only the technical officers of the various branches of survey but also representatives of the user and operating services as well, and they provide a forum where difficulties, present and prospective, can be discussed and solutions suggested.

From the Council's staff, technical experts in almost every line can be brought in for consultation and advice; expert chemists to advise on plate emulsions and developers, inks for printing and paper to meet the special needs of maps; physicists on lenses and other optical devices; engineers on mechanical problems, such as are presented in the axis bearings of precise theodolites; skilled designers who can take the general ideas suggested for new devices and work them into apparatus which is practically realizable, and last, but not least, a very competent workshop in which these new instruments can be constructed to a degree of precision and finish which compares favourably with the best that Europe can turn out.

This committee has behind it a long record of useful accomplishments, and, by way of example, I mention one item of the work of the Subcommittee on Contouring from Air Photographs and Instruments for Plotting. I refer to the radial line plotter which has now been completed and put into use. This machine has cut the time required for the measurement of detail on vertical photographs in half, so that there is no doubt that our investment in time and money will be well repaid. The instrument cost us $2,842 to build, and this went largely to Canadian workmen. Alternatively, we estimate that at least $21,000 would have been required if the contract for the machine had been let abroad and then we would have failed to acquire that knowledge and experience which only goes to those who essay to launch out and pioneer a new development.

The experience gained in this venture alone is more than worth the whole cost because it gives confidence in undertaking to find, ourselves, the answer to the many special problems that face us in the mapping of the vast spaces of Canada—problems which differ both in degree and in kind from those of any other country on earth. If we waited for others to produce the answers we require, we would wait in vain. Therefore, I say to you that research is not the least important of the duties that fall to the attention of those who are responsible for survey in Canada.

Another example is a very useful improvement developed by the Subcommittee on Photographic Aircraft, the multi camera mount. This, in addition to tripling the number of photographs from a given flying time, has resulted in giving us co-ordinated sets taken from the same point in space from which the required measurements can be determined with great facility. I would say, conservatively, that in operations where oblique photography is required this improvement alone has reduced air survey costs by at least one half.

In the foregoing remarks, I have been thinking of the air photographs in terms principally for supplying topographical information for maps. But the air photograph is useful for many other purposes as well. We think that now we should be able to carry forward a traverse for considerable distances without even having to go on the intervening ground at all. To help in the investigation of this problem, a special instrument, known as a stereogoniometer, was designed by Mr. Fourcade, a South African. In collaboration with our own technical officers the design of this instrument has recently been modified to suit our special requirements and, thanks to the generosity of the Imperial Oil Company, funds have been provided for its construction, and an order has been placed with Messrs Barr and Stroud in England.

In the other fields as well the closest attention has been given to the development of new methods and instruments, and some important improvements have been made. However, it is clear that the greater share of the credit for the remarkable increase in the rate of production, as well as in the quality of our maps, undoubtedly belongs to air survey, and is reflected in the fact that in the whole history of Canada up to 1922 only some 240,000 square miles of our territory, mostly in the settled portions, had been mapped. Since 1922, and the arrival of the air photograph, 481,000 square miles have been mapped and this area lies mostly in the more difficult unsettled regions, where, previous to the development of the air, it was impossible to do any detailed survey at all. For this north country, the air has wiped out a frontier and opened new lands for economic development. In 1935, the freight carried by air into these parts exceeded 26 million pounds, a figure which represents six-sevenths of all the freight carried by air in the whole British Empire; this year it is estimated that an increase of over one-third will be realized.

If time had permitted, I would have liked to refer to the uses being found for air photographs in forest inventory work; in the study of road, railway and transmission line location; in the geological field for ascertaining the position of faults in the earth's surface so that prospectors may be guided to the most likely areas of mineralization; in water power development; in city planning—to mention only a few of the wide variety of services which now make use of air photographs.

To give point to the economic value of this work, I would mention that some of the photographs in the national collection have been put to over twenty separate uses in a single year. The average is estimated at over ten uses for each photograph. In one case in Manitoba, as a result of information obtained, an important new road to a mining area was shortened by 31 miles at a saving of $5,000 to $7,000 per mile—the saving on this one project alone exceeding the total cost of all photographic flying in Canada for the year.

The wide diversity in the application of air photographs means that the costs chargeable to any one service are proportionately reduced, thereby extending the possibilities for economic use.

I think I have said enough to indicate in a general way the value, the economic importance and the economy which comes from the use of air photographs. For all this benefit to Canada, we are primarily indebted to the officers and other ranks of the Royal Canadian Air Force, who have carried out the difficult and, ofttimes, dangerous flying involved, who have borne cheerfully and without complaint the hardships inseparable from prolonged operations far away from civilization, and who have contributed from their great experience to the technical developments which have taken place, and to the training of all concerned in their use.

In conclusion, I would observe that, through the various sub-committees of the Survey Research Committee, we are closely in touch with similar work being carried out in Great Britain, in the United States, and on the continent of Europe, and that the committee is alert to seize upon and turn to our own advantage any new development which may take place.

I assure you that this committee and the National Research Council are anxious to assist you in any and every way which may be possible.

## The Great Flood of 1936 in New England

Following the floods of July, 1935, in the New York State, floods rising to unprecedented heights inundated the river valleys of the North-Eastern States of the United States of America. Between March 18th and March 21st, 1936, nearly every river, large and small, in the 200,000 square miles of country from the Canadian boundary to Virginia and Ohio created new records of flood heights and peak-flow volume, submerging the lower districts of the valley cities and carrying havoc and destruction on their way.

The rainfall was due to a series of cyclones which traversed this area, causing heavy rain and snow. There was a heavy snowfall during the winter months and such rains as fell were held by the snow cover. During the first fortnight of March there was a succession of warm days, which loosened the snow cover. Heavy rain in the second week of March caused floods in several smaller rivers, the larger rivers began to rise almost to "bank-full stage," and the thick ice on the rivers began to break up. On the afternoon of March 17th, heavy rain fell in the nothern area of New England, followed by a general downpour throughout the eastern states.

Pinkham Notch, New Hampshire, in the White Mountains, registered nearly 8 inches of rainfall on March 12th and 13th, with a maximum daily temperature of 44 degrees. During the next week, from March 17th to 19th, the same station registered nearly 10 inches of rainfall and a daily temperature of 47 degrees.

The major streams affected were the Potomac in Maryland, the Ohio from Pittsburgh to Cincinnati, the Allegheny and Monongahela in Pennsylvania, the Susquehanna in New York and Pennsylvania, the Connecticut, the Merrimac, the Androscoggin, the Kennebec and the Penobscot in New England, and the St. Johns River in Canada. The unprecedented heights reached, the magnitude of the area and the number of populous cities affected by submersion, ranks the inundation as one of the major catastrophies of the United States.

The Potomac River, at Harpers Ferry, on March 18th, rose to a height of 36.6 on the river gauge, the previous highest level recorded being 36.0 in 1889. At Hancock, higher up the river, the water reached a level of 47.5 on the gauge, nearly 8 feet above the level reached in 1889.

Pittsburgh, Pennsylvania, at the junction of the Alleghany and the Monongahela rivers, has always been subject to floods. Because of the immense losses so sustained, the Pittsburgh Flood Committee was formed to study methods of preventing the recurrence of such disasters, particularly that of 1907. The Committee submitted its report in 1911, and predicted a future flood stage of 43.0, based on a probable flow of 634,000 cusecs from the two rivers.

On Monday, March 16th, 1936, at 8.0 a.m., the river gauge stood at 19.8, with a rising river; by 8.0 a.m. of the 17th, the water had risen to 24.7; on the 18th, 8.0 a.m., it had risen to 42.0; and by 7.0 p.m. a maximum stage of 46.0 was reached, and stood at this height for four hours, the crests of the floods in the two rivers arriving simultaneously at Pittsburgh. By 6.0 p.m., March 20th, the river stage had fallen to 25.0. The estimated flood discharge of the river at stage 46.0 was 640,000 cusecs, which slightly exceeded the predicted maximum flood discharge. The high stage of 46.0 might have been due to obstructions and encroachments on the stream and to navigation dams, or to a reduced flood slope.—*Engineering.*

# BRANCH NEWS

## Border Cities Branch

*J. F. Bridge, A.M.E.I.C., Secretary-Treasurer.*
*F. J. Ryder, Jr.E.I.C., Branch News Editor.*

After the regular dinner meeting of the Border Cities Branch, Professor Geo. J. Higgins, Ae.A., of the University of Detroit, spoke on "Archery."

The container for holding arrows usually holds ten to twelve arrows. In medieval days the quiver held twenty-four arrows, and each archer had two quivers.

Arrows are made of all kinds of material, depending on personal ideas and theories. The broadhead type, so-called because of the shape of the arrowhead, predominates. These may be of two types, the barbed or the barbless, both types being used for hunting. The blunt head arrow is used for practice and target arrows have special heads. Long distance or flight arrows have small vanes and are usually longer and lighter than the ordinary arrow.

Bows vary in shape and size. The long-bow equals the height of the owner, the strength depending on the length of arm and the strength of the individual. The old English archers drew their bowstrings to their ear, but present day archers draw to their chin and line the string with the target, their sight thus giving them the plane of flight. The short-bow is coming more and more into prominence as it is more easily handled, especially for hunting purposes.

An archer's equipment consists of a quiver with arrows, a variety of bows, a bracer which is worn on the wrist to protect it from the vibrations of the bowstring after release, and finger protectors for the hand that holds the bowstring.

A hunter using a bow and arrow must stalk his game as well as shoot it. Indians were good hunters not because of their skill with a bow and arrow but because of their cleverness in stalking game.

Most distance shooting is done with a very strong bow, the bow being held by the feet while the archer lies on his back, elevates his bow to the correct angle and draws the bowstring back with his hands. All old records for long distance shooting have been surpassed by this style of shooting.

Scientists and physicists are now at work studying archery and trying to design bows that give a maximum performance with a minimum amount of effort.

Roy C. Leslie, A.M.E.I.C., moved a hearty vote of thanks to Professor Higgins, which was seconded by E. M. Krebser, A.M.E.I.C., and unanimously approved by all present.

## Calgary Branch

*James McMillan, A.M.E.I.C., Secretary-Treasurer.*

### Overhead Conductor Vibration

The first meeting of the Calgary Branch in 1937 was held on January 14th. At this meeting, W. J. Gold, Jr.E.I.C., spoke on "Overhead Conductor Vibrations" discussing in detail the causes of vibration, particularly in the case of steel reinforced aluminum conductor, and the methods used to combat vibration. By means of illustrations and samples Mr. Gold showed the application of the "festoon" method, Stockbridge dampeners and armour rods and their effectiveness in reducing conductor vibration. At the conclusion of the talk a number of members contributed to an interesting discussion of the use of dampening devices, especially armour rods.

### Annual Joint Dinner

On January 23rd the Renfrew Club, Calgary, was the scene of the annual joint dinner of The Calgary Branch of The Engineering Institute of Canada, the Association of Professional Engineers of Alberta, and the Rocky Mountains Branch of the Canadian Institute of Mining and Metallurgy. This event is arranged each year by a committee of members of each organization and contributions towards the expenses are made by each organization. At this year's dinner, P. Turner-Bone, M.E.I.C., one of the oldest engineers in Alberta both in years and in service, was chosen as chairman, and Mr. A. E. Ottewell, Registrar, University of Alberta, was selected as guest-speaker. Mr. Ottewell took as his subject "Nothing Remains to be Done," and in his talk he covered briefly the advances made by the various professions, advances so marvellous and so, relatively, progressive that it would seem as if nothing further needed to be done while actually so much still remains to be done in engineering and other professions. About one hundred engineers attended this enjoyable function.

### Sound Natural and Unnatural

The Branch general meeting on February 11th was addressed by A. T. McCormick, A.M.E.I.C., who took as his subject "Sound, Natural and Unnatural." This talk was supplemented by diagrams and curves projected on a screen and also by a special gramophone which was used to bring out the effect of sound suppression above and below certain frequencies. Mr. McCormick's talk was followed by a very interesting discussion.

Beet Sugar Refining

On March 4th a joint meeting of the Calgary Branch and the Junior Section of the Calgary Board of Trade was addressed by Mr. F. H. Ballou, chief engineer, Canadian Sugar Factories, Ltd. and B.C. Sugar Refining Co., Ltd., Vancouver, on "Beet Sugar Refining" and "Construction of the Picture Butte Sugar Factory." Mr. Ballou commenced his address by enumerating the factors to be considered in selecting a site for a beet sugar factory and explained how the site chosen at Picture Butte fulfilled these conditions. The speaker described the methods of construction used and the equipment installed in the various parts of the sugar factory. The total investment made is about $1,500,000. In concluding his talk Mr. Ballou made a strong plea to those present to aid the beet sugar industry in Southern Alberta by using beet sugar. After the talk a number of pictures illustrating the construction of the Picture Butte factory were shown and various points were explained by Mr. Ballou.

The talk and showing of pictures were followed by an interesting discussion in which several members took part. One of the points brought out in the discussion was that, contrary to popular opinion in some quarters, there is absolutely no difference between beet sugar and cane sugar. R. S. Trowsdale, A.M.E.I.C., in moving the vote of thanks to Mr. Ballou, pointed out the importance of the beet sugar industry in the economic situation of Southern Alberta and advocated the support of this industry.

## Edmonton Branch

*M. L. Gale, A.M.E.I.C., Secretary-Treasurer.*
*F. A. Brownie, Jr.E.I.C., Branch News Editor.*

The annual mixed meeting of the Branch was held on February 16th, 1937, when members entertained their wives and friends at dinner in the Corona hotel.

Branch Chairman E. Stansfield, M.E.I.C., presided, and after a very short business meeting introduced the guest speaker, Captain E. R. Gibson of the Alpine Club of Canada. Captain Gibson chose as his subject "Climbing on the Great Divide." His talk was illustrated with many excellent slides, and he drew from a wealth of personal experience for the material of his address.

The speaker described the climbing of many well-known peaks in the Jasper area, including the great Mount Robson. Several of the climbs were "first ascents." Particularly difficult was the ascent of Mount Clemenceau on account of its isolated position. The two previous ascents of this peak had been accomplished by fairly large parties, well equipped and using horses. Captain Gibson's party was small, unassisted by horses, and carried only what was possible by back-packing. The Athabasca river formed one of the worst hazards of the expedition, but was crossed by the ingenious use of a raft and the climb completed without serious mishap.

Of particular local interest was the detailed account of the accident on Mount Geikie, when an Edmonton doctor broke his leg. He was forced to spend a very cold night on the mountain-side, and his subsequent rescue down steep rock and snow slopes proved both difficult and hazardous.

The address was much enjoyed by the audience, and J. D. Baker, M.E.I.C., moved a vote of thanks to the speaker.

## Hamilton Branch

*A. R. Hannaford, A.M.E.I.C., Secretary-Treasurer.*
*W. W. Preston, S.E.I.C., Branch News Editor.*

Vancouver Jubilee Fountain

The new policy of the Papers committee of the Hamilton Branch was well received at the general meeting held at McMaster University on February 19th, 1937. The speaker at most previous meetings has come from outside the city, but on this occasion two local engineers addressed the Branch, G. F. Mudgett, manager of the illuminating division of the Canadian Westinghouse Company, an outstanding authority on illumination, and J. T. Thwaites, Jr.E.I.C., who has had wide experience in thermionic control, spoke on the design and operation of the Jubilee fountain designed by Mr. McKenzie, and recently erected in Stanley Park, Vancouver. The popularity of the meeting was apparent from the fact that the attendance of ninety-five included several ladies.

Mr. Mudgett, who was introduced by the chairman, E. G. MacKay, A.M.E.I.C., described the appearance of the fountain. It is a monument of classical architecture, set in the middle of a lagoon with rustic background. The structure is built of concrete on a foundation of long piles. There is a lower basin of 40-foot diameter, and an upper basin of 14-foot diameter. From these two levels, five individual water effects are produced. A stream of water varying in height from nil to 135 feet issues from a 28 mm. nozzle in the centre of the upper pool. Around the edge of this pool there is a ring 13 feet in diameter, with a hundred and thirty-two 10 mm. nozzles. The water rising therefrom gives the appearance of a vertical cylinder with a height up to 35 feet. Around the lower pool there are eight rings, each 4 feet in diameter, and each has a 10 mm. nozzle at its centre. These central jets rise to a maximum height of 35 feet and the water cylinders surrounding them to a height of 20 feet. The remaining individual water effect is a parabolic dome which is formed by streams from three hundred and ten nozzles inclined 15 degrees to the vertical in a ring 35 feet in diameter around the lower pool. All streams are floodlighted in varying colours. The lights are under water in hermetically sealed, aluminum cases, each with a single coloured lense. By changing the intensity of illumination of the various coloured floodlights, and by varying the heights of the different water streams, it is estimated that there are about two and a half million different effects being produced continually.

Mr. Thwaites explained why the $32,000 fountain performed in the manner described by his colleague. This speaker discussed the method employed to control the gradual variations in water pressure on the nozzles and then outlined the difficulties of choosing a lighting control that would give smooth changes in illumination. Flashing, he stated, was an undesirable control because of its abruptness. Dimming by the familiar resistance method was also objectionable, due to high power losses and to the large number of costly resistance steps required. Reactance dimming, in which d.c. flows around the iron core of the reactance as a.c. passes through it, gives a wide range of control with little power loss, but cannot be employed unless d.c. is available. When the only source is a.c. thermionic tubes are used as rectifiers. It is this last control that is used on the Jubilee fountain. The complex cycle on which variations in water pressure and coloured lighting operate was described. Although the cycle is automatic it is possible to insert a manual control unit. The power consumption for all controlling devices totals only 40 watts. Peak load is 38.6 kw.

Throughout the lecture lantern slides were shown, and at the close a demonstration on the mixing of coloured lights was given. Unfortunately, colour filming will not give a satisfactory picture of this fascinating fountain in Stanley Park, Vancouver.

The vote of thanks to the speakers was moved by H. A. Lumsden, M.E.I.C., and the meeting adjourned for refreshments.

The Manufacture of Cold Drawn Wire

A meeting of the Hamilton Branch was held at McMaster University on March 10th, 1937.

The speaker was A. B. Dove, A.M.E.I.C., a member of the Branch, whose subject was "The Manufacture of Cold Drawn Wire and Some Factors Affecting its Physical Properties."

Mr. Dove, who is a chemical engineer engaged with the Canada Works of the Steel Company of Canada in Hamilton, was introduced by the chairman, Col. E. G. Mackay, A.M.E.I.C.

Wire has become a highly specialized product and to illustrate the scope of the wire industry the speaker said that one of his firm's customers calls for two hundred and eighty-one different sizes and grades of wire.

Specifications for such special products demand accurate tests of the material in all its processes from the open hearth furnace to the finished wire.

The McQuaid-Ehn test which was developed in 1922 was explained with the help of a series of lantern slides. After the material is carburized the outer layers are examined under a microscope to determine the size of the grains; the material is then classified by a number which indicates one of eight standard grain sizes. This test is of major importance because the properties of the metal are definitely related to the grain structure.

The rod coming from the rolling mill has a mill scale that must be removed before the rod can be drawn through the die; this is removed by pickling but this process exposes the rod to hydrogen embrittlement. This condition is overcome by the rod passing through a further process of liming and baking.

The rod then goes to the drawing blocks and next passes through the dies, which are of special design, and so is finally reduced to the required size. The throat of the nozzle shaped die must be of a definite angle for each particular grade of material so that the wire will not break in the die.

Before the drawing operation the grains have a cubical shape but as the wire passes through successive reduction dies the grains assume a needle like shape, lying in the direction of flow of the metal.

A further operation of annealing or patenting, depending on the carbon content of the material, may be employed to relieve a grain stress and permit further working of the material to bring it to the required size.

Finally the wire is tested for such qualities as tension, elongation, hardness, torsion, crimping and bending, depending, of course, on the purpose for which the wire will serve.

The speaker stated that under a continuous load or strain a wire would undergo a change of grain structure, thus its physical properties would change. For this reason, particularly, the greatest care should be exercised in the choice or selection of wire for each particular purpose.

A hearty vote of thanks was accorded Mr. Dove for the interesting manner in which he had presented his subject to an audience of fifty-five members and visitors.

The meeting adjourned for refreshments and this usual feature of the Branch was enjoyed until a late hour.

## London Branch

*D. S. Scrymgeour, A.M.E.I.C., Secretary-Treasurer.*
*Jno. R. Rostron, A.M.E.I.C., Branch News Editor.*

The regular monthly meeting of the Branch was held on February 25th, 1937, in the Public Utilities Commission Board Room at the City Hall, the speaker being G. Harold Reavely, M.A., D.I.C. (London), Assistant Professor of Geology at the University of Western Ontario, London.

The chairman of the Branch, A. O. Wolff, M.E.I.C., presided and after the reading of the minutes which were unanimously adopted he called on H. F. Bennett, M.E.I.C., chairman of the newly formed Papers Committee, to report progress. Mr. Bennett explained the aims and objects of the Committee and said so far they had met with success and already had one or two favourable responses from prospective speakers and they hoped soon to have a complete programme for the entire year. He also urged members to contribute papers.

SOME GEOLOGICAL PRINCIPLES AFFECTING THE ENGINEER

Professor Reavely pointed out that chemistry and physics were fundamental to geology as also to engineering and that often the trained engineer was not conversant with geology. Among the important questions which the engineer has to consider are the character of rocks for building and road material; for tunnelling operations; dam and reservoir foundations; landslides, etc.; the geological conditions affecting and controlling underground water supplies and the relation of soils to sewage disposal and water purification. Some familiarity with materials on fuels, clays, cements is necessary.

In considering rocks from the standpoint of road construction it is necessary to study the character of the rock and its structure. Clays are likely to give much trouble owing to expansion if wet and shrinkage if dry.

All rocks contain joint and other types of planes and may slide along any of these if unsupported. If water is present frost causes a great tendency towards slipping.

Local sources of supply are usually drawn upon for road construction and broken stone may be any kind of rock included in the igneous, sedimentary or metamorphic groups but the minerals which make up these may be divided into two classes, viz., primary and secondary. The former include quartz, feldspar, pyroxens, amphibolite, biotite, muscovite, calcite, dolomite, garnet, olivene, etc. The latter chlorite, kaolinite, sericite, limonite, serpentine, epidote and sometimes calcite and quartz. The weathering properties are important and depend upon the mineral composition and not the hardness. Granites have several features mitigating against their best use alone as road metals. They are of low toughness and low cementing value, their texture is granular rather than interlocking and contain platy mica; thus they are liable to fall apart. They should not be exposed to the traffic but placed in the foundation.

Regarding building stone the selection of material is wide, but the properties governing this selection are different. One of the most important features is texture. This is the result of the physical aggregation and size of the mineral crystals and particles which compose the stone. It may be coarse, fine, even grained, porphyritic or dense or porous. Coarse grained rocks disintegrate more rapidly than fine grained and porphyritic more than even grained. This is due to the different expansion of the individual minerals. Rocks containing more pyritic minerals should never be selected for building stone, chemical products of oxidation ($H_2SO_4$) dissolve the rock material.

In addition, the speaker described the three main divisions of rocks, the structures in rocks and something about underground waters.

An interesting discussion followed the speaker's remarks, and a vote of thanks was proposed to Professor Reavely by E. V. Buchanan, M.E.I.C., seconded by H. F. Bennett, M.E.I.C., and unanimously carried.

## Montreal Branch

*E. R. Smallhorn, A.M.E.I.C., Secretary-Treasurer.*

THE ENGINEER AND NON-FERROUS ALLOYS

At the meeting of the Montreal Branch held on February 25th, 1937, H. J. Roast, F.C.S., F.C.I.C., M.E.I.C., vice-president in charge of technical operations for the Canadian Bronze Company and its subsidiaries, presented an interesting paper which dealt particularly with the necessary relations between design, pattern making and casting of non-ferrous alloys. Useful general information was also given concerning these alloys, and an explanation as to their use. The paper was illustrated with slides.

H. W. B. Swabey, M.E.I.C., was in the chair.

JUNIOR SECTION

At the meeting of the Junior Section held on March 1st, two papers were presented, one by Yvon Deguise, S.E.I.C., a student in his final year at the Ecole Polytechnique, Montreal, entitled "L'Application des relais pour la protection des lignes des transmissions," and one by M. J. Lupton, S.E.I.C., who is on the staff of the Dominion Bridge Company, Limited, Lachine, on "Further Research on the Residual Stresses Set up by Welding."

Mr. W. Horwood acted as chairman.

LARGE PIPE LINES WITH SUPPORTING RING GIRDERS

E. C. Molke, A.M.E.I.C., and A. W. F. McQueen, A.M.E.I.C., who are both with H. G. Acres and Company Limited, Niagara Falls, Ont., addressed the Montreal Branch on March 4th, their subject being the design problems of an 18-foot diameter steel penstock, which is at present being constructed in connection with the Comeau Bay development of the Ontario Paper Company.

Previous to the meeting an informal dinner was held at the Windsor hotel.

The chairman was M. V. Sauer, M.E.I.C.

TELEMETERING

On March 11th, Mr. P. A. Borden, development engineer for the Bristol Company of Waterbury, Conn., addressed the Branch, his subject being "Telemetering." The speaker described metering by the current, voltage, frequency and position systems. The talk was illustrated by lantern slides.

An informal dinner was held at the Windsor hotel prior to the meeting.

Graham Kearney, M.E.I.C., was in the chair.

JUNIOR SECTION

At the meeting of the Junior Section held on March 15th, J. M. Cape, S.E.I.C., a member of the engineering staff of E. G. M. Cape and Company, presented a paper on "The Theory and Application of Sliding Forms in Concrete Structures having Thin Walls," and W. E. Griffiths, Jr.E.I.C., presented one which dealt with "The Handling of Concrete in the Field."

Hugh Gordon, S.E.I.C., was chairman.

APPLICATION OF NEGATIVE REGENERATION IN COMMUNICATION

On March 18th, C. B. Fisher, A.M.E.I.C., radio receiver engineer for the Northern Electric Company Ltd., in Montreal, spoke on the principle of negative regeneration, which is one of the most important technical advances in electrical communication in recent years. The paper was illustrated and demonstrations were made of some of the phenomena involved.

J. H. Thompson, A.M.E.I.C., was in the chair.

ALL WELDED STEEL HIGHWAY BRIDGE

At the meeting of the Montreal Branch held on March 25th, P. Brault, A.M.E.I.C., of the Dominion Bridge Company Limited, presented a paper dealing with the design, fabrication and erection of the new all welded steel highway bridge over the Ste. Anne river at Ste. Anne de la Perade. This bridge is a six-span continuous deck plate girder type.

Huet Massue, A.M.E.I.C., acted as chairman.

## Niagara Peninsula Branch

*P. A. Dewey, A.M.E.I.C., Secretary-Treasurer.*
*C. G. Moon, A.M.E.I.C., Branch News Editor.*

AIR COMPRESSORS—SELECTION AND DESIGN

The February meeting of the Niagara Peninsula Branch was held on the 18th at the Fox-head Inn, Niagara Falls.

G. H. Wood, A.M.E.I.C., graced the chair, while vice-chairman L. C. McMurtry, A.M.E.I.C., was on hand to introduce the speaker.

Councillor E. P. Murphy, A.M.E.I.C., and the chairman reported upon their trip to the Annual Meeting in Montreal.

E. T. Harbert, A.M.E.I.C., of the Canadian Ingersoll-Rand Company, presented a paper dealing with the selection and design of air compressors. Illustrated by means of lantern slides, this paper discussed reciprocating compressors and their relation to modern industry, giving examples of varying types with figures of their energy losses and regulation. The subject of valves, and valve actions, was given special consideration.

R. A. Bradley, A.M.E.I.C., expressed the thanks of the meeting to the speaker for his able handling of a complex subject.

At the close of the meeting, a session of the Executive was held to discuss general business and to make arrangements for subsequent meetings.

## Ottawa Branch

*F. C. C. Lynch, A.M.E.I.C., Secretary-Treasurer.*

ADDRESS BY PRESIDENT

An event of outstanding interest to the Ottawa Branch was the noon luncheon on February 25th, 1937, at which G. J. Desbarats, C.M.G., Hon.M.E.I.C., president of The Institute, addressed the members upon Institute affairs. Mr. Desbarats, a resident of Ottawa, has long been a member of The Institute, his period of membership ante-dating by a dozen years the formation of the Ottawa Branch in 1909.

J. G. Macphail, M.E.I.C., chairman of the Branch, in his introduction, referred to the career of Mr. Desbarats both as an engineer and as a public servant up to the time of his retirement a few years ago from the position of Deputy Minister of the Department of National Defence. Mr. Desbarats, in acknowledging the introduction, stated that he felt the office of president for the 1937 year was one of particular responsibility in that The Institute was celebrating the Semicentennial anniversary of its formation during the summer.

The speaker then briefly traced the history of the organization since its formation dealing with its growth from a mere 288 members at first to its present status with headquarters at Montreal and 25 branch organizations extending from Sydney, Nova Scotia, to Victoria, British Columbia. A point brought out in this history was the fact that at the time of the commencement of the Great War in 1914 the membership was about 2,800 of which 950 or more than one-third enrolled for overseas service. Of these 119 never returned.

A considerable portion of the president's address was taken up in reviewing the various steps that had been taken to date toward arranging for the consolidation of The Institute with the various provincial engineering associations.

Fifty years is a short period in the life of an organization of this kind, stated Mr. Desbarats at the conclusion of his address, but during that time engineering has completely revolutionized our manner of living. "Progress has indeed been great," he concluded, "and it is to the members of this Institute, and particularly to the younger members, one looks to see that the progress of the future measures up to that of the past. It is our lot to contribute a very vital part to the advance of civilization, the improvement of social security, and the happiness of mankind."

The luncheon was well attended both by members of The Institute and others who wished to pay tribute to the distinguished speaker. At the head table in addition to the chairman and the speaker there were: Major General A. G. L. McNaughton, M.E.I.C., president of the National Research Council; F. C. Green, M.E.I.C., Surveyor General of British Columbia, Victoria, B.C.; Hon. Michael Dwyer, A.M.E.I.C., Minister of Mines of Nova Scotia; George H. Desbarats, A.M.E.I.C., Low, P.Q.; K. M. Cameron, M.E.I.C., Commander C. P. Edwards, A.M.E.I.C., Noel Ogilvie, M.E.I.C., Dr. R. W. Boyle, M.E.I.C., Major General T. V. Anderson, A.M.E.I.C., Lieut. Col. G. R. Turner, A.M.E.I.C., Group Captain E. W. Stedman, M.E.I.C., and John McLeish, M.E.I.C.

Engineering in Agriculture

"Engineering in Agriculture" was the subject of the noon luncheon address on March 11th at the Chateau Laurier, the speaker being E. S. Hopkins of Ottawa, Dominion Field Husbandman of the Dominion Experimental Farms.

Dr. Hopkins, at the commencement of his address, enumerated various ways wherein engineering knowledge was called into use in connection with farming operations. Drainage, irrigation, the design of farm buildings, farm machinery, the utilization of farm power, studies in relation to electrification, water erosion, soil drifting control and flood control were some of the ways listed.

In times of depression, a solution commonly advocated for the employment of those who have lost their positions in the cities and towns is to place them out on farm lands. Those who propose such measures lose sight of the fact that farming is becoming a more highly specialized occupation, requiring capital, assurance of revenue, a knowledge of machinery, education, good physical condition, and many other things. Furthermore with the increased use of machinery and mechanization generally there has been a marked decrease for years in the proportion of those engaged in rural occupations.

According to the last census figures, there was one tractor for every seven farms in Canada. In the Prairie Provinces the figures were one tractor for every three farms. With the increased mechanization there is a tendency to increase the size of the farms themselves.

Showing the effect of the size of farm holdings, Dr. Hopkins stated that it had been determined in investigations carried on in Western Canada in 1930 that when a quarter-section of 160 acres was devoted to the production of wheat the cost of production was about $1.02 per bushel. When larger acreages were farmed for the same purpose costs were respectively: 80 cents per bushel for a half section, from 63 to 77 cents per bushel for a full section, and from 51 to 55 cents per bushel for two to three sections, depending upon the nature of the equipment used. Some might deplore carrying on farming operations in a large way, but it must be considered in the light of what the farmer himself can make out of it.

Although agriculture on first sight does not seem to be a very competitive line of business, yet looked at in a broad national and international way it is very much so. In the future farming will tend to become more specialized, and will more and more require the aid of specialized knowledge. The engineer will accordingly occupy a greater part than he already has, and his services will be called upon to a greater extent in connection with the many engineering aspects of agriculture.

J. G. Macphail, M.E.I.C., chairman, presided at the luncheon and in addition head table guests included: G. J. Desbarats, Hon. M.E.I.C., Murray Clark, M.P., Dr. H. T. Gussow, Dr. A. Gibson, L. L. Bolton, M.E.I.C., E. Viens, M.E.I.C., T. A. McElhanney, A.M.E.I.C., Robert Brindley, P. Sherrin, A.M.E.I.C., Maxwell Tobey, M.E.I.C., C. L. O'Brien and Alan K Hay, A.M.E.I.C.

## Peterborough Branch

*W. T. Fanjoy, A.M.E.I.C., Secretary-Treasurer.*
*E. J. Davies, A.M.E.I.C., Branch News Editor.*

The first meeting of the Peterborough Branch for this year was a supper meeting held at the Kawartha Club House on January 14th. Members brought as guests young engineers who were prospects for membership in The Institute. The meeting was under the chairmanship of H. R. Sills, A.M.E.I.C., who called on R. L. Dobbin, M.E.I.C., vice-president of The Institute. Mr. Dobbin outlined aims and objectives of The Institute and explained to the prospective members reasons why they should become affiliated with this organization.

Nepheline Cyanite

Mr. H. R. Deeth, manager of the Canadian Nepheline Cyanite Co. of Lakefield, gave a short address on "Nepheline Cyanite" which is now being manufactured at Lakefield. Nepheline cyanite is a natural rock formation found on Blue Mountain, Methune Township, Peterborough County. It looks like granite and is used in the glass industry after it has been finely ground. The grinding is done in part of the old Canada Cement plant at Lakefield. The producers of this powder claim that it greatly clarifies the manufactured glass.

After the address the student and junior section of this branch was reorganized and then the members and guests spent the balance of the evening at bridge or ping pong.

Electric Welding

On Thursday, January 28th, the members of this Branch were addressed by Mr. H. Thomasson, engineer on electric arc welding, Canadian Westinghouse Co., Hamilton. Mr. Thomasson has been actively engaged in electric arc welding for many years and has followed its development from the crudest possible methods to its present status. He told of great recent improvements in methods and of the advance effected in the substitution of composition-coated welding rods for the older type of straight metal welding rods. He spoke of the new use of alternating current in seam welding. As alternating current of the lower cycles in common use is of no use, 100,000 cycle current is superimposed.

Referring to a popular make of 4-door sedan cars, Mr. Thomasson said the completed job contains 3,415 separate welds. A typical six and one-half cubic foot refrigerator has 1,509 welds in its construction.

The operation of a great automatic seam-welding machine which will fasten two large sheets of metal together much as a sewing machine fastens together two pieces of cloth, was explained. The two edges of metal to be welded pass between two power rollers. Intermittent arcs weld a solid seam as the rollers pull the metal through.

Electric welding played an important part in the construction of a great liner for the first time in history as welding was employed almost throughout in the construction of the great *Queen Mary*.

General Electric House of Magic

The General Electric "House of Magic" visited Peterborough on February 17th and 18th, under the joint auspices of The Engineering Institute, Kiwanis Club, and Social and Athletic Club of the Canadian General Electric. The demonstration was in charge of Mr. Wm. A. Gluesing. The term "House of Magic" was applied to the General Electric Laboratories at Schenectady, N.Y., in 1928 and these laboratories employ nine hundred workers including three hundred scientists, technicians and physicists.

Responding to general public demand the company built a miniature "House of Magic" on wheels. A similar unit to the one in Peterborough was a feature of the Century of Progress Exposition at Chicago, where Mr. Gluesing exhibited it for two years. It was also at the Canadian National Exhibition and in New York City.

Among a whole series of amazing demonstrations that were presented by Mr. Gluesing in rapid succession, and which held his audience enthralled, polaroid, the new material that enables light to travel only in one plane was demonstrated publicly for the first time, and one cannot but be impressed with the apparent number of commercial possibilities which it offers.

When two sections of this glass-like material are placed against each other it is possible by changing the relative positions of the two pieces of polaroid to either pass light or stop it.

Using the phototube or what has come to be known as the "electric eye," Mr. Gluesing picked up the music of a phonograph from a light beam and converted the light back into sound through a loud speaker.

The current from the phonograph pick-up was so arranged that it travelled to a lamp on a tripod, the sound waves being transformed into light. The lamp having the ability to go on and off hundreds of thousands of times to the second transmitted an ever-changing beam of light equivalent to the notes of the phonograph record. Focussed on the receiving end of a phototube pick-up at the other end of the stage, however, the light was turned back to music. Mr. Gluesing played many uncanny tricks with the light beam, cutting off the music at will, or diminishing the sound.

In another experiment which demonstrated the versatility of the phototube, Mr. Gluesing used it to turn the light of an incandescent tube into sound—flickering on and off one hundred and twenty times a second, too fast for the human eye to observe, but slow enough for the ear to hear.

The voice-controlled electric train which Mr. Gluesing operated by such words as "come ahead again old man," "back-up" and "stop" was among some of the more uncanny demonstrations. The demonstrator explained that he did not rely on the use of any particular word in the control of his train, but the use of certain syllables properly timed.

Other experiments performed by Mr. Gluesing included high frequency radiations, lighting an electric lamp with a match, the cathode-ray oscillograph, and "invisible" light.

This demonstration was very popular and filled the house, accommodating eight hundred and fifty people, at four performances.

## Sault Ste. Marie Branch

*N. C. Cowie, Jr.E.I.C., Secretary-Treasurer.*

The Sault Ste. Marie Branch of The Engineering Institute of Canada held a general meeting at the Windsor hotel, Sault Ste. Marie, Ontario, on Friday, February 19th, 1937.

An enjoyable dinner was served by the hotel staff to twelve members and five guests at 7.15 p.m.

C. W. Holman, A.M.E.I.C., chairman of the Branch, called the meeting to order at 3.00 p.m. The minutes of the previous meeting, a few items of business, which included the auditors' report by H. O.

Brown, A.M.E.I.C., and a short talk by the chairman of the Membership Committee, A. H. Russell, A.M.E.I.C., were dealt with by the meeting.

W. A. Dawson, A.M.E.I.C., chairman of the Papers and Publicity Committee, then introduced the speaker of the evening, W. M. Reynolds, A.M.E.I.C.

Mr. Reynolds, who was with the God's Lakes Mines in charge of construction during the erection of the Kanuchuan power development, then told the members of this project.

Mr. Reynolds dealt chiefly with the unusual difficulties that had to be overcome during the construction of a power development north of latitude 53. Mr. Reynolds' paper was of great interest to the members present and was followed by an interesting discussion which brought up other interesting features of this development.

The members, through E. M. MacQuarrie, M.E.I.C., and A. H. Russell, A.M.E.I.C., thanked Mr. Reynolds for his very entertaining and interesting paper.

## Toronto Branch

*W. S. Wilson, M.E.I.C., Secretary-Treasurer.*
*D. D. Whitson, A.M.E.I.C., Branch News Editor.*

### Transportation Methods in Use in Northern Ontario

At the meeting of the Toronto Branch held on January 7th, 1937, at Hart House, the members of the Branch had the pleasure of hearing two addresses on "Transportation Methods in Use in Northern Ontario." D. Forgan, A.M.E.I.C., of the Ontario Hydro-Electric Power Commission, dealt mainly with the transportation problems encountered in the construction of northern hydro power developments, stating that the transportation costs had, for some plants, amounted to 40 per cent of the total cost of construction. Diesel tractors pulling trains of sleighs and cabooses under very difficult operating conditions was a favourite method after freeze-up had occurred, and water transportation by scow and tug previous to freeze-up, with the assistance of marine railways to get the scows over the many portages was the other main method used for the transport of heavy material or large quantities of supplies.

Mr. W. A. Scott, of Canadian Airways, on the same evening opened the eyes of most of those present to the enormous strides that air transport is making in the heretofore "inaccessible" northland. A load of many hundred pounds of mail, supplies, food or accessories to be carried to destinations two or three hundred miles distant is everyday performance for our airways, either in winter or in summer. In certain cases, boilers weighing many hundred pounds and cows have been transported by air. The Canadian Airways maintain several radio stations, keep in touch with the planes, and give extremely valuable broadcasts on weather conditions. Both Mr. Forgan and Mr. Scott had many fine slides to illustrate their talks and a point stressed by both speakers was that over 70 per cent of the entire country has no rapid means of travel available except by the use of the airplane.

### Power Development in Northern Ontario

On January 21st, the Toronto Branch met at Hart House with O. Holden, A.M.E.I.C., in the chair, and had the pleasure of hearing a paper by Dr. T. H. Hogg, M.E.I.C., Chief Hydraulic Engineer of the Hydro-Electric Power Commission of Ontario on "Power Development in Northern Ontario." The address was fully illustrated by slides and was read by Mr. Holden in the unavoidable absence of Dr. Hogg. All varieties of power plants were discussed, including their location, length of transmission line, costs, ice difficulties, etc. This paper appeared in full in the March, 1937, issue of The Engineering Journal.

### Arc Welding, Its Testing and Inspection

At the meeting of the Toronto Branch held at Hart House on February 4th, a most interesting address on "Arc Welding, Its Testing and Inspection" was given by W. D. Walcott, A.M.E.I.C., Inspecting Engineer with the Hydro-Electric Power Commission of Ontario. Mr. Walcott covered the subject most fully, and had some fine slides to illustrate his talk. Messrs. Bonn and Hamilton took an active part in the lively discussion which followed the address.

### Electrical Equipment for the Abitibi Canyon Development

On February 18th, the Toronto Branch met at Hart House with O. Holden, A.M.E.I.C., in the chair. W. E. Ross, A.M.E.I.C., of the Canadian General Electric Company, presented a paper on the "Fabrication and Installation of the Electrical Equipment for the Abitibi Canyon Development." Illness prevented the author from being present, and his paper was read by Mr. F. C. Barnes of the same company.

Emphasis was placed on the great influence of transportation limitations on the design and shop fabrication of such large generators and transformers as are installed at Abitibi, particularly when one considers that this development is approximately 600 miles north of Toronto in virgin country. How successfully these limitations were overcome was clearly shown by the author, as the equipment was installed and placed in commercial operation without any difficulties, except of a very minor nature.

The paper was illustrated by slides showing scenes at the site, with views of the canyon before any construction was started, followed by pictures of progressive stages during installation, and final views of the plant as it went into operation.

A series of views of the hydraulic equipment was also shown, having been loaned by the turbine manufacturer.

The paper also included a complete description of the high and low voltage switching equipments, station service facilities, and the control and relay protective systems.

## Vancouver Branch

*T. F. Berry, A.M.E.I.C., Secretary-Treasurer.*
*J. B. Barclay, A.M.E.I.C., Branch News Editor.*

### Joint Meeting with A.I.E.E.

A joint meeting of the Vancouver Branch of The Institute and the Vancouver Section of the American Institute of Electrical Engineers was held on Tuesday, January 26th, 1937. About a hundred and twenty members of the two organizations and visitors were in attendance. The speaker was Mr. J. F. Lincoln, President of the Lincoln Electric Co. of Cleveland, Ohio.

Mr. Lincoln addressed the meeting on "Modern Developments in Electric Arc Welding." He described the early difficulties in arc welding practice due to oxidation and how these difficulties had been overcome by the use of the shielded arc rod by which method it was now possible to obtain welds as strong and stronger than the parent metal with consistent performance.

Mr. Lincoln showed some interesting lantern slides describing the application of arc welding to the manufacture of electric motor frames, bases and end rings, and compensator boxes etc., together with the comparative costs of manufacturing these machine parts both by cast metal and welded construction. The cost of fabrication in each case was in favour of welded construction, sometimes by wide margins. At the conclusion of the lecture Mr. Lincoln replied to many questions from his audience concerning the welding of stainless steels, aluminum, mild steel to cast iron and other problems of practice and design that present themselves to engineers. A vote of thanks was proposed by H. N. Macpherson, M.E.I.C., chairman of the Vancouver Branch E.I.C., and seconded by Mr. Bartholomew, of the Vancouver Section A.I.E.E.

### Vancouver's Traffic Problems

Twenty-six members and guests of the Vancouver Branch sat down to dinner at the Hotel Grosvenor on the evening of February, 11th. Following dinner, the members were addressed by Inspector Harold Mortimer, Superintendent of Vancouver Police Traffic Department, on "Vancouver's Traffic Problems."

Inspector Mortimer stressed the need of the education of the public to an appreciation of the fact that traffic laws and regulations are for their convenience and safety, and that only by the wholehearted co-operation of the public will traffic codes be effective in this regard. Vancouver's toll from traffic accidents in 1936 was 35 fatal and 1,749 hospital cases and it was the speaker's contention that the majority of there accidents were avoidable had intelligence and necessary vigilance been employed by the motoring public. The speaker dealt with the many phases of traffic control in a large city—parking regulations, control of pedestrian traffic, the several types of traffic signals, the relation of the street car to auto and pedestrian traffic, "through streets" and uniform highway and street signs. Following the lecture, Mr. Randolph Martin, traffic engineer of the City of Vancouver Engineering Department, briefly addressed the meeting on the functions of the traffic engineer. The balance of the evening was given over to the discussion of this most vital problem of the modern city.

## Winnipeg Branch

*H. L. Briggs, A.M.E.I.C., Secretary-Treasurer.*

### Colour Photography

At the meeting of the Winnipeg Branch held on February 18th, 1937, the chair was occupied by A. E. Macdonald, M.E.I.C.

Approximately one hundred and seventy-five members heard Dr. Alexander Gibson present the paper "Colour Photography."

Historically, Clerk-Maxwell superimposed three photographs, each of which recorded one of the three photographic primary colours—red, green and blue. Then Lumiere combined the process into one picture-taking operation by covering the film surface with a large number of small starch particles which had been dyed the different colours. Dufay further improved the method by using coloured lines ruled across the surface of the film, 20 to the millimeter, in two sets at right angles to each other.

The kodachrome process uses three colour sensitive layers, separated by neutral layers, all on the same film base. Each layer is responsive to light rays of one colour. In developing, the metallic silver obtained proportionally to the light intensity on a given area is dissolved out, and its place taken by dye of the appropriate colour and in proportional amount.

A large number of colour slides were shown of English, American and Canadian scenes, slides illustrating the process described, also two kodachrome films taken locally by Dr. C. H. Goulden.

E. V. Caton, M.E.I.C., expressed the appreciation of the audience to the speaker.

### Students' Prize Papers

At the meeting of the Winnipeg Branch held on March 4th, 1937, S. V. Antenbring, S.E.I.C., presented a paper entitled "Locating the

Control for a Detailed Geological Survey," which dealt with the methods used last summer in the Rice lake area of Manitoba. The whole area worked over was staked with mining claims. The claim posts as shown by the surveys of the claims were used as preliminary control points for the work, which was done mainly by plane table although the chain and compass method had to be used in certain places. Traverses were set up radiating from the claim posts, from which a grid system two hundred feet to a side was laid out and marked on the ground. Geologists then used this grid for plotting their information.

"Air Conditioning in Railway Cars" by J. J. Miller, S.E.I.C., dealt with equipment which was placed in a number of cars at the Transcona shops of the Canadian National Railways last summer. An electric fan picked up the stale air from suitable locations, forcing it through cooling coils or heating coils as desired, then through air filters, and through two main duct systems, one to the main part of the car and the other connecting with the individual berths. Three ice boxes, each holding 2,700 pounds of ice, were used for cooling.

Those taking part in the discussion included Messrs. A. I. Bereskin, Jr.E.I.C., D. M. Stephens, A.M.E.I.C., G. H. Herriot, M.E.I.C., E. P. Fetherstonhaugh, M.E.I.C., and N. M. Hall, M.E.I.C. G. E. Cole, A.M.E.I.C., moved the vote of thanks.

Before the presentation of the main papers, Professor G. H. Herriot thoroughly entertained the Branch by recalling a number of his early surveying experiences in the Peace river country of Alberta, and in Manitoba.

## Periodicals in Institute Library

(Continued from March Journal).

Listed below is the balance of periodicals which are received regularly by The Institute Library, and which are available for reference purposes in the reading room. The first part of this list appeared on page 155 of the March issue of The Journal.

Engineering Progress.
English Electric Journal.
Experiment Station Record—U.S. Dept. of Agriculture.
Factory Management and Maintenance.
Financial Post, The.
The Foundation-Engineering Society of Detroit.
G.E.C. Journal.
General Electric Review.
General Manager's Bulletin, Kenya and Uganda Railways and Harbours.
Génie Civil, Le.
Heating and Ventilating.
Heating, Piping and Air Conditioning.
Highway Magazine, The.
Houille Blanche, La.
Highway Research Abstracts—Highway Research Board.
Indian Engineering.
Industrial and Engineering Chemistry.
Industrial Britain.
Industrial Canada.
Industrial Standardization.
De Ingenieur.
International Conciliation.
Iron Age, The.
Iron and Steel of Canada.
Journal of the Aeronautical Sciences.
Journal of the American Concrete Institute.
Journal of the American Water Works Association.
Journal of the American Welding Society.
Journal, Boston Society of Civil Engineers.
Journal of Engineering Education.
The Canadian Banker.
Journal of the Franklin Institute.
Journal of the Institution of Civil Engineers.
Journal, Institution of Electrical Engineers.
Journal of the Institution of Engineers Australia.
Journal, Institution of Municipal and County Engineers.
Journal of Research—U.S. Bureau of Standards.
Journal of the Royal Aeronautical Society.
Journal, Royal Architectural Institute of Canada.
Journal of the Royal Artillery.
Journal of the Royal Society of Arts.
Journal, Society for the Advancement of Management.
Journal of the Society of Automotive Engineers.
Journal, South African Institution of Engineers.
Journal of the Western Society of Engineers.
Junior Institution of Engineers—Proceedings.
Library Bulletin of Abstracts.
Lubrication.
MacLeans Magazine.
Marketing.
McGill News, The.
Mechanical Engineering.
Mémoires et Compte Rendu des Travaux.
Mining and Metallurgy.
Modern Power and Engineering.
Monthly Bulletin (Canadian Chamber of Commerce).
Monthly Bulletin (Maritime Teleg. and Teleph. Co.).
Monthly Commercial Letter, Canadian Bank of Commerce
Monthly Review, the Bank of Nova Scotia.
Monthly Weather Review, U.S. Dept. of Agriculture.
Municipal Reference Library Notes.
National Geographic Magazine.
Overseas Engineer.
Paper Trade Journal.
Pennsylvania Engineer.
Philippine Engineering Record.
Power.
Power Notes.
Power Plant Engineering.
Proceedings, American Society of Civil Engineers.
Proceedings, Canadian Railway Club.
Proceedings of Cleveland Institution of Engineers.
Proceedings, Institute of Radio Engineers.
Proceedings, Royal Society of Edinburgh.
Proceedings, South Wales Institution of Engineers.
Professional Engineer.
Public Roads.
Pulp and Paper of Canada.
Quarterly Digest of Current Asphalt Literature.
Railway Age.
Refrigeration and Air Conditioning.
Review of the Activities of the Montreal Board of Trade.
Revista de la Sociedad Cubana de Ingenieros.
Revue Trimestrielle Canadienne.
Roads and Streets.
Rochester Engineer.
Royal Bank of Canada Monthly Letter.
Royal Engineers' Journal, The.
Special Libraries.
Steel Constructor.
The Structural Engineer.
La Technique Moderne.
Toronto Industrial News Bulletin.
Trade and Engineering.
Transactions of American Society of Mechanical Engineers.
Transactions of the Institution of Engineers and Shipbuilders in Scotland.
Transactions of the Mining Institute of Scotland.
Transit Journal.
United Empire.
University of Illinois Bulletin.
University of Toronto Monthly.
V.D.I. Zeitschrift.
Water Works and Sewerage.
Wood Preserving News.
World Convention Dates.
World Power.

## American-Operated Air Lines Carry 1,147,969 Passengers in 1936

Air lines operated by American companies (domestic and foreign extensions) carried 1,147,969 passengers and 8,350,010 pounds of express during the calendar year 1936.

Of the total number of passengers carried in 1936 there were 1,020,931 who travelled on the domestic air lines and 127,038 who flew on extensions to foreign countries.

In 1935 the American-operated air lines carried 860,761 passengers and 5,511,737 pounds of express.

Miles flown by all scheduled operators in 1936 were 73,303,836 as compared with 63,540,233 flown in 1935. Passenger-miles flown in 1936 were 491,744,053 and for 1935 this figure was 360,569,431. A passenger-mile is the equivalent of one passenger flown one mile.

There were 380 airplanes in operation on the scheduled air lines at the end of the year. The air lines furnished employment for 9,972 persons (as of December 31st) classified as follows: 690 pilots, 543 co-pilots, 2,864 mechanics and ground crew men, 1,764 other hangar and field personnel, 3,721 operations and office personnel, 287 hostesses, and 103 stewards.

The domestic lines had 106,774 flights scheduled of which 100,335 were started. There were 4,702 extra sections flown and the total number of trips completed was 100,420. Of all trips started the air lines completed 95.6 per cent.

The average speed for all domestic air lines at the end of the year was 151 miles per hour, and the average length of a passengers trip was 427 miles. Of seats which were available, 64 per cent were used.

—*Air Commerce Bulletin.*

# Preliminary Notice

### of Applications for Admission and for Transfer

March 27th, 1937

**The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.**

**It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.**

**In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.**

**If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.**

**Communications relating to applicants are considered by the Council as strictly confidential.**

The Council will consider the applications herein described in May, 1937.

R. J. Durley, Secretary.

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*The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years inthe case of a candid ate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of,age, and shall have been engaged in some branch of engineering for at least six years which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch ofengineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more year.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard.

**A Student** beshallat least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.

FOR ADMISSION

BOUCHARD—JEAN, of St. Hyacinthe, Que., Born at St. Hyacinthe, Sept. 28th, 1904; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1931; 1926, 28, 29 (summers), student engr., River St. Lawrence Ship Channel; 1931, 3 mos. with Quebec Streams Commission, and 3 mos. with Quebec Roads Dept.; 1932 to date, city engineer, St. Hyacinthe, Que.
References: A. Frigon, O. O. Lefebvre, N. B. McLean, T. J. Lafreniere, A. Duperron, C. K. McLeod.

CANTIN—L. ARTHUR, of 1106 Sherbrooke St. East, Montreal, Que., Born at St. Romuald, Que., April 17th, 1900; Educ., B.Sc. (E.E.), Tri-State College of Engrg., Angola, Indiana, 1932; 1925 (Jan.-Aug.), Coyne Electr'l School, Chicago; 1925-26, electrn. on constrn. and mtce., International Harvester Co., Chicago; 1926-29, elect'l. constrn. and mtce. (mtce. foreman for last 18 mos.) Aluminum Co. of Canada, Arvida, Que.; 1929 (Sept.-Dec.), control and high tension work, Shawinigan Engrg. Co., Grand Mere, Que.; 1929-30, elect'l. constrn. and mtce., Dominion Rubber Co., St. Jerome, Que.; 1930, installn. of electric elevators, Otis Fensom Elevator Co. and Turnbull Elevator Co., Montreal; 1933, electr'l constrn. and motor repairs (private business); 1933-34, power house constrn., Shawinigan Engrg. Co., Rapide Blanc, Que.; 1934 (June-Nov.), electr'l. constrn. and mtce., Aldermac Mines Ltd., Arntfield, Que.; Nov. 1934 to date, i/c electr'l. mtce. for Canadian Lastex Ltd., Montreal, Que.
References: M. S. Macgillivray, G. Townsend, B. K. Boulton, T. M. Moran, R. Ford, R. E. Heartz.

DAVIES—CLARENCE EBENEZER, of Bronxville, N.Y., Born at Utica, N.Y., March 15th, 1891; Educ., M.E., Rensselaer Polytechnic Institute, 1914; 1916-17, engr. of manufacture, as chief rate setter and prod. superviser in charge of engrg. for improving mfg. methods, Remington Typewriter Co.; 1919-20, with same company as special engr. at Ilion, N.Y., and production superviser at Syracuse, N.Y.; 1917-18, asst. supt. prod., artillery ammunition dept., Frankford Arsenal, and 1918-19, supt. of fuse shop; March 1920 to date, with The American Society of Mechanical Engineers, successively as associate editor; managing editor and assistant secretary; executive secretary and secretary, being appointed to the latter office in December 1934.
References: H. B. Oatley, L. K. Sillcox, S. L. Kerr, H. H. Vaughan, T. K. Thomson.

HOGG—THOMAS, of 1839 Retallack St., Regina, Sask., Born at Ushaw Moor, Co. Durham, England, Nov. 7th, 1904; Educ., 1923-25, Technical College, Sunderland, Durham. National Certificate, Institution of Mechanical Engineers, 1925; With Messrs. Pease & Partners Ltd., Ushaw Moor and Esh Winning, Durham, as follows: 1919-25, pupilage to mech'l. engrg.; 1925-27, asst. engr. to the chief engr.; 1927-28, in charge of erection of steam, compressed air and pumping plant; designed and supervised constrn. of steel housing for same; 1926-28, in charge of all dfting and supervision of mech'l. design at Ushaw Moor; Dec. 1930 to May 1936, chief dftsman., Dept. of Natural Resources, Regina, Sask., including design of general engrg. works for the various branches of the dept. Recently transferred (on loan) to the Water Rights Branch, Regina, work includes supervision of design for structures for irrigation projects and stock-watering dams, and gen. engrg. work under the Prairie Farm Rehabilitation Act.
References: C. J. McGavin, H. J. deSavigny, T. G. Tyrer, J. C. Todd, J. W. D. Farrell, H. A. Jones.

HOVEY—CHARLES MANSUR, of Suite 3. Ludlow Apts., Winnipeg, Man., Born at Rock Island, Que., Oct. 3rd, 1913; 1931-33, completed second year engrg., Univ. of Man.; 1933-35, machinist, Winnipeg Brass Co. Ltd.; 1935-36, machinist, Manitoba Bridge and Iron Works; At present, laboratory technician, depts. of civil and mech'l. engrg., University of Manitoba, Winnipeg, Man.
References: N. M. Hall, A. E. Macdonald, G. H. Herriot, E. V. Caton, F. G. Goodspeed, J. F. Cunningham.

KIRKBRIDE, DAVID SPENCER, of 2229 Cornwall St., Regina, Sask., Born at Calgary, Alta., Aug. 15th, 1913; Educ., B.Sc. (Civil), Univ. of Sask., 1934; 1934 (summer), rodman, Sask. Dept. of Highways; 1935 (summer), dftsman., on plans for Ceepee Bridge, Ceepee, Sask.; 1935-37, junior engr., Dept. Public Works, Canada, Ceepee, Sask.; At present working towards M.Sc. in Civil Engrg., at Univ. of Saskatchewan.
References: C. J. Mackenzie, F. G. Goodspeed, R. A. Spencer, A. R. Greig, W. E. Lovell.

LAVERTY—CLARENCE ALVIN, of 5009 Cote des Neiges Rd., Montreal, Que., Born at Limestone, N.B., Jan. 9th, 1903; Educ., B.Sc. (E.E.), Univ. of Alta., 1928; 1923-25 (summers), survey work in Nor. Canada; 1928-30, ap'ticeship course, Canadian Westinghouse Company, Hamilton, Ont.; 1930-31, with service dept. of same company at Montreal, handling, under direction of dist. engr., repair and installn. of electr'l. equipment; 1931 to date, elect'l. inspector, Boiler Inspection and Insurance Co. of Canada, Montreal. Inspection of and reporting upon condition of elect'l. equipment, also supervision of repairs to insured equipment.
References: J. Palmer, F. C. Woods, H. R. Webb, H. J. MacLeod, R. W. Boyle.

McEWEN—MARKLAND NEIL, of Kenora, Ont., Born at Togo, Sask., Mar. 23rd, 1911; Educ., B.Sc. (C.E.), Univ. of Man., 1932; 1928, subforeman, bdg. constrn.; 1929, 1930, rodman, constrn. dept., C.P.R.; 1932 to date with the Dept. of Northern Development of Ontario as follows: 1932-33, dftsman., 1933-34, instr'man., 1934-35, res. engr., 1935 to date, instr'man.
References: E. A. Kelly, T. C. Macnabb, E. P. Fetherstonhaugh, J. N. Finlayson, G. H. Herriot, F. Petursson.

NESBITT—WILLIAM P., of Edmundston, N.B., Born at St. Catharines, Ont., Nov. 10th, 1911; Educ., B.Sc. (Mech.), Queen's Univ., 1935; 1931-33, lab. asst., 1933-34, office asst., master mechanic, and 1935-36, gen. machine and mtce. work, Alliance Paper Mills; At present, junior engr., engrg. dept., Fraser Companies Ltd., Edmundston, N.B.
References: R. E. Smythe, D. S. Ellis, L. T. Rutledge, L. M. Arkley, F. O. White, J. E. Cade.

O'SHAUGHNESSY—PATRICK LEO, of Belleville, Ont., Born at Newcastle, N.B., Nov. 7th, 1898; Educ., B.Sc. (Civil), McGill Univ., 1923; 1923, struct'l. steel dftsman., Canadian Vickers Ltd.; 1924-28, Deputy Land Surveyor, New Brunswick; 1928-37, plant engr., and at present mill foreman, Plant No. 5, Canada Cement Co. Ltd., Belleville, Ont.
References: J. A. Creaser, T. R. Durley, C. W. Edmonds, W. L. Saunders, E. R. Smallhorn, H. J. Leitch, G. R. Stephen.

POITRAS—PAUL E., of 4189 Northcliffe Ave., Montreal, Que., Born at St. Henri de Mascouche, Que., May 1st, 1892; Educ., B.A.Sc., C.E , Ecole Polytechnique, Montreal, 1915; 1915-16, struct'l. steel tracer and detailer, and 1916-19, mech. drawing, detailer and designer, Dominion Bridge Co. Ltd., Montreal; 1919-20, gen. engrg., Canada Cement Company, Montreal Harbour Commissioners; 1920 to date, with the

Steel Co. of Canada Ltd., Montreal, mech. drawing and industrial engrg., gen. plant engrg., layout of steam power houses and industrial bldgs., as asst. engr., and at present, mech. engr.

References: A. Mailhiot, E. C. Kirkpatrick, J. A. Lalonde, H. Massue, E. A. Ryan, B. R. Perry, J. H. Landry.

SHERWOOD—BENJAMIN H., of 328-4th Ave. East, Calgary, Alta., Born at Calgary, Jan. 11th, 1913; Educ., B.Sc. (E.E.), Univ. of Alta., 1935; dftsman., engrg. dept., Imperial Oil Ltd., Calgary, Alta.

References: J. J. Hanna, R. W. Dunlop, R. MacKay, R. S. L. Wilson, H. J. MacLeod, C. A. Robb.

STRINGER—REGINALD JOHN, of Calgary, Alta., Born at Newport, Isle of Wight, Oct. 26th, 1899; Educ., 1922 to date, studied both theoretically and practically, oil engines, marine and stationary, in all phases of their application; 1916-17, junior dftsman., Pimm & Boughton; 1917-19, dftsman., R.A.F.; 1919-21. dftsman., Accumulators of Woking Ltd.; 1922-24, engr., at sea with fishing companies; 1924-25, engr. at sea on motor ship; 1926-27, engr. on installn. and overhauling oil engines, Wallace Shipyards, B.C. Marine Shipyards, Vancouver, B.C. Packers Co., etc.; 1928, erecting engr., Asser Diesel Co., Vancouver; 1928-29, engr., with B.C. Electric Co., Bridge River; 1930, designed, installed engine and built plant of Creston Light & Power Co., Creston, B.C.; 1930 to date, supervising engr. in charge of oil engine plants, Canadian Utilities Ltd., Calgary.

References: E. W. Bowness, F. J. Heuperman, J. Haddin, P. F. Peele, R. S. Trowsdale.

VAISON—ALBERT FELIX, of 122 Gilmour St., Ottawa, Ont., Born at Aix, B. du R., France, Apr. 27th, 1884; Educ., 1899-1903, Naval College, Brest; 1913-14, asst. engr. on constrn. of two largest drydocks in France, also constrn. of reinforced concrete barges, at Toulon, France; 1917, transforming destroyers and other ships into oilburners; 1918, in charge of refitting and re-engining German ships for use as troopships; 1919-20, in charge of wooden shipbldg. for French High Commission U.S.A. and Canada, Seattle, Portland, Vancouver, etc.; 1920 to date, technical adviser to the Dept. of National Revenue (Customs Division) to advise the Minister and the Commissioner on all questions requiring engineering knowledge and experience. To make surveys of ships or machinery, land power plants, etc., To investigate and discuss with heads of industrial plants engineering problems which may have a bearing on the tariff status of imported machinery, equipment, raw materials, etc.

Reference: J. L. Busfield, R. Ramsay, A. E. MacRae, E. Viens, J. E. Porter, F. J. Bell.

#### FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

BURNS—CHARLES HENRY McLEOD, of 105 Dorothy St., Welland, Ont., Born at Amherst, N.S., Oct. 21st, 1889; Educ., 1909-11, Mt. Allison Univ.; 1911-12, asst. to mech. engr. on power plant and concentrator constrn.; 1912-20, res. engr. with Maritime Coal Railway & Power Co. Ltd., Nova Scotia; 1920-24, designing engr. on mine plant and equipment, and mech'l. handling equipment, Link-Belt Co., Philadelphia; 1924-28, with same company in charge of plant changes, design and constrn. of new plants, and changes in mfg. methods in steel shops, mach. shops, grey iron and steel foundries; 1928-29, designing engr., International Nickel Co. of Canada, Copper Cliff, Ont.; 1929-31, chief engr., Dodge Mfg. Co. Ltd., Toronto; 1931-32, inspr. for Ontario Power Service Corpn. on power development project at Abitibi Canyon, Ont.; 1932-34, consltg. mech'l. engr.; 1935 to date, asst. mgr. in charge of operation and mtce. of drop forging and heavy forging plants of Canada Foundries and Forgings Ltd., Welland, and also direction of all technical research and control. (*A.M. 1920.*)

References: W. J. Ripley, P. C. Kirkpatrick, H. T. Kirkpatrick, R. E. Smythe.

NICHOLSON—JOHN BILLINGTON, of Scarsdale, N.Y., Born at Hamilton, Ont., Dec. 5th, 1890; Educ., B.A.Sc., Univ. of Toronto, 1914; 1913, constrn. of bldgs., Oliver Chilled Plow Works; 1913, Toronto Hamilton and Buffalo Rly. City of Hamilton, Hydro-Dept., bldg. electric transmission lines; 1915-26, vice-president in charge of design and constrn., J. B. Nicholson Ltd. and The Nicholson Company, New York; 1926 to date, president, The Nicholson Company, New York. Sole owner and entire charge of engrg. constrn., grain elevators, coal pockets, elevator storage constrn., etc. Also president, J. B. Nicholson Ltd., Toronto, and president, Fairmont Constrn. Co., New York. (*Jr. 1914, A.M. 1917.*)

References: R. L. Latham, F. W. Paulin, J. J. MacKay, H. M. Campbell, N. E. D. Sheppard.

#### FOR TRANSFER FROM THE CLASS OF JUNIOR

LLEWELLYN—LEOPOLD WILLIAM, of 2848 Retallack St., Regina, Sask., Born at Kilkenny, Ireland, May 19th, 1902; Educ., B.Sc. (Mech.), Univ. of Sask., 1927; 1924-26 (summers), rodman, dept. of highways, Regina, Sask.; 1927-28, dftsman., Canadian Westinghouse Company, Hamilton, Ont.; 1928-29, surveyor and inspr., Montreal Engineering Co., Regina; 1929-30, dftsman., Vancouver Engrg. Co., Vancouver; 1930, dftsman., B.C. Electric Rly., Vancouver; 1931, asst. engr., city engr's. dept., Moose Jaw, Sask.; 1932, pipeline inspr., waterworks dept., Regina; 1933, elec. supt. and asst. to supt., World's Grain Show, Regina; 1934 to date, designer with Northwestern Iron Works Ltd., on design and production of of the "Ross Diesel Cylinder Head." (*Jr. 1929.*)

References: H. C. Ritchie, J. W. D. Farrell, D. A. R. McCannel, A. P. Linton, R. W. Allen, A. R. Greig.

#### FOR TRANSFER FROM THE CLASS OF STUDENT

CHARLEWOOD—CHARLES BENJAMIN, of 10 McKenzie St., Galt, Ont., Born at Toronto, Ont., Aug. 10th, 1908; Educ., B.Sc. (Mech.), McGill Univ., 1931; 1929 (summer), rodman and instr'man., constrn. survey, C.P.R.; 1930 (summer), student, Laurentide Divn., Canada Power and Paper Corpn., Grand Mere, Que.; 1931 (June-Nov.), production foreman, radio manufacture, Victor Talking Machine Co., Montreal; 1931-32, service engr., Canadian Diesel Engine Corpn., Montreal; 1932-34, surface labour, underground pumpman and mechanic, Noranda Mines Ltd., Noranda; 1934 (Feb.-Oct.), steam and power clerk, Cons. Paper Corpn., Shawinigan Falls; 1934-36, lubrication foreman, boiler operator, Noranda Mines Ltd.; At present, engr., Babcock-Wilcox & Goldie-McCulloch Ltd., Galt, Ont. (*St. 1931.*)

References: E. A. Allcut, J. R. Bradfield, L. F. Grant, A. R. Roberts, D. B. Simpkin.

KERSHAW—NORMAN WILLIAM, of Drummondville, Que., Born at Saskatoon, Sask., Mar. 14th, 1913; Educ., B.Sc. (Mech.), Univ. of Sask., 1933; 1932 (summer), ap'tice electrn., J. M. Taylor, Saskatoon; 1933-34, instructor in mech. engrg. lab., Univ. of Sask.; 1934-35, asst. to asst. factory mgr., oilcloth divn., Dominion Oilcloth and Linoleum Ltd.; 1935-1937, mech. engr., and Jan. 1937 to date, asst. factory mgr., Eagle Pencil Co., Drummondville, Que. (*St. 1935.*)

References: C. J. Mackenzie, R. A. Spencer, W. G. Worcester, A. R. Greig, W. E. Lovell, I. M. Fraser.

LAING—DAVID ALEXANDER SHEARER, of 5865 Notre Dame de Grace Ave., Montreal, Que., Born at Dundee, Scotland, Mar. 22nd, 1906; Educ., B.Sc. (Mech.), McGill Univ., 1930; 1923-24, foundry and tool making, Lunkenheimer Valve Co., Cincinnati; 1924-25, gen. machinist, Curtiss Aero and Motor Corpn., Long Island, N.Y.; 1925-26, installn. and service, Socony Oil Burner Corpn., New York; 1930-31, tool and gauge design, and 1934 to date, cable engrg. and development, Northern Electric Co. Ltd., Montreal. (1931, Pilot Officer, R.C.A.F., Camp Borden, Ont.). (*St. 1930.*)

References: R. E. Jamieson, C. M. McKergow, N. L. Dann, W. H. Eastlake, A. J. Lawrence, S. R. McDougall, N. L. Morgan.

MANN—OSWALD NELSON, of Drummondville, Que., Born at Sydney, N.S., Sept. 8th, 1912; Educ., B. Eng. (Mech.), N. S. Tech. Coll., 1935; 1934 (summer), helper in shops, Dom. Steel and Coal Corpn., Sydney, N.S.; 1935 (summer), dftsman. and timekpr., Sydney Foundry and Machine Works Ltd.; 1935-37, asst. chemist and asst. meter engr., Imperial Oil Refinery, Dartmouth, N.S.; At present, asst. plant engr., Eagle Pencil Co. of Canada, Drummondville, Que. (*St. 1936.*)

References: R. L. Dunsmore, W. E. Clarke, M. Dwyer, I. P. MacNab, S. Ball.

McKENZIE—RALPH BAYNTON, of 1230-5th Ave. South, Lethbridge, Alta., Born at Lethbridge, Apr. 23rd, 1908; Educ., B.Sc. (Chem.), Univ. of Alberta, 1932; 1929-30 (summers), ditch surveyor, Lethbridge Northern Irrig. Dist.; 1931 (summer), and 1933-35, asst. chemist, Maple Leaf Petroleum Ltd., Coutts, Alta.; At present, elect'l. contracting, estimating, salesman, etc., McKenzie Electric Ltd., Lethbridge, Alta. (*St. 1932.*)

References: P. M. Sauder, J. T. Watson, W. L. McKenzie, N. H. Bradley, J. Haimes, W. Meldrum.

ROMBOUGH—JOSEPH HAROLD MELVILLE, of 231 Arthur St., Oshawa, Ont., Born at Smiths Falls, Ont., July 28th, 1908; Educ., B.Sc. (Civil), Queen's Univ., 1931; 1929 (summer), assting. O.L.S. in Aultsville, Ont.; 1930-32, asst. city engr., Sudbury, Ont., in charge of field and office work relating to all municipal local improvements; design, plans, layout and inspection of reinforced concrete bridges, culverts and retaining walls; At present, labourer in tapping dept., Fittings Limited, Oshawa, Ont. (*St. 1928.*)

References: D. S. Ellis, W. L. Malcolm, W. P. Wilgar. G. J. Smith, J. E. Goodman.

STANLEY—THOMAS DOUGLAS, of Calgary, Alta., Born at High River, Alta., July 10th, 1908; Educ., B.Sc. (Arts), 1929, B.Sc. (E.E.), 1932, Univ. of Alta. M.Eng. (Elec.), McGill Univ., 1933. 1933-34, extra post-graduate year at Univ. of Alta., selected courses in civil and elect'l. engrg.; 1928-34, sessional demonstrator in physics, Univ. of Alta.; With the Calgary Power Co. Ltd., Calgary, Alta., as follows: 1935 (summer), and 1936 (2 mos) hydrometric survey and collection of stream flow data; Sept, 1935-Mar. 1936, floorman and mtce. man., Ghost River plant; 1936 (2 mos), constrn. dept.; July 1936 to date, compilation and computation of stream flow data. (*St. 1932.*)

References: G. H. Thompson, H. J. McLean, J. McMillan, R. S. Trowsdale, R. S. L. Wilson, H. J. MacLeod.

TWEEDDALE—REGINALD ESTEY, of Arthurette, N.B., Born at Arthurette, Dec. 24th, 1914; Educ., B.Sc. (E.E.), Univ. of N.B., 1935; 1932-33-34 (summers), highway constrn. work; 1935, transitman on topog'l. survey party; 1935 to date, instr'man. on location and constrn., N.B. Dept. of Highways. (*St. 1935.*)

References: A. F. Baird, J. Stephens, E. O. Turner, J. E. Cade, S. R. Weston.

WISE—ALFRED JOHN, of 6648 Third Ave., Rosemount, Que., Born at Brighton, England, Sept. 27th, 1906; Educ., B.Sc., McGill Univ., 1927. Post-graduate at Univ. of Pittsburgh for M.S. completed except thesis exam.; 1924-26 (summers), and 1927-28, Montreal Tramways Co., rolling stock divn., all phases of equipment mtce.; 1928-29, test course, Westinghouse Electric and Mfg. Co., Pittsburgh; 1929-31, with same company at Homewood, Pa., as production engr. with redesign of defective and obsolete auxiliary equipment of rating machines; 1931-32, design engr. for aluminum electric trans. lines and substations, Aluminum Ltd., Montreal; 1935-36, with H.H. Cantwell, A.M.E.I.C., consltg. engr., as appraiser and evaluator of textile and paper mills; At present with the Canadian Underwriters Assn., as inspr. and consltg. elect'l. engr. for member companies. (*St. 1925.*)

References: C. U. Vessot, A. J. Foy, J. E. Thicke, H. H. Cantwell, T. H. Bacon, W. H. Cook.

## List of New and Revised British Standard Specifications

(Issued during January, 1937)

530—1937. *Graphical Symbols for Telephony, Telegraphy and Radio Communication.* (*Revision.*)
Revision bringing 1934 edition into line with the International Electrotechnical Commission publication (I.E.C. No. 42-1936).

720—1937. *Standard Method for the Calibration of Carburettor Jets for Petrol Engines (all types) (for Flows not exceeding 2,000 ML. per minute).*
Supersedes B.S.S. No. 5030-1925, gives particulars of the standard reference jet calibrator and jets deposited at the National Physical Laboratory and information as to construction, installation, use and maintenance of the commercial carburettor jet calibrator.

722—1937—*Borehole and Well Pump Tests.*
One of a series covering the determination of the performance and efficiency of borehole pumps and well pumps when handling water at temperatures up to 85 degrees F.

723—1937. *Sewage Pump Tests.*
One of a series covering the determination of the performance and efficiency of sewage pumps (i.e. pumps handling liquids having appreciable amounts of solid matter in suspension) when handling liquid at temperatures up to 85 degrees F.

724—1937. *Vaporising Liquid Pump Tests.*
One of a series covering the determination of the performance and efficiency of condensate extraction pumps, hot water boilers for pump feed and other purposes and pumps for petrol and other similar volatile liquids but not air lift pumps and those for foaming liquid such as beer.

725—1937. *Hot Rolled Mild Steel Strip (or Hoop) not exceeding 10 inches wide for General Engineering Purposes.*
Covers a commercial quality of hot rolled mild steel strip (or hoop).

Copies of the new specifications may be obtained from the Publications Department, British Standards Institution, 28, Victoria Street, London, S.W.1, England, and from the Canadian Engineering Standards Association, 79 Sussex Street, Ottawa.

## EMPLOYMENT SERVICE BUREAU

The Service is operated for the benefit of members of The Engineering Institute of Canada, and for industrial and other organizations employing technically trained men—without charge to either party.

*All correspondence should be addressed to*

**The Employment Service Bureau, The Engineering Institute of Canada**

**2050 Mansfield Street, Montreal**

## Situations Vacant

DRAUGHTSMAN, general draughtsman with some experience in pulp and paper mill work. Apply to Box No. 1520-V.

INSTRUMENTMAN, with experience in layout and construction of roads and streets. Location province of Quebec. Apply to Box No. 1521-V.

DESIGNERS AND DRAUGHTSMEN, on pulp and paper mill plant extensions. Location province of Quebec. Apply to Box No. 1523-V.

DESIGNER, experience in the design of transformers, to act as assistant in design department. Location Ontario. Apply to Box No. 1527-V.

ELECTRICAL ENGINEER, experience in the erection of switchboards, panels, and electrical equipment generally. Location Ontario. Apply to Box No. 1528-V.

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THE NATIONAL RESEARCH COUNCIL has under consideration the establishment of a position in the Radio Section of the Laboratories under the auspices of the Associate Committee on Radio Research. The Salary will be $1,800 per annum, and the appointment will be made for one year.

The duties of the position will be to assist with research and test work undertaken by the National Research Council.

Candidates must be University Graduates, either in Electrical (Radio) Engineering, or Physics, with special training in radio, and preferably with some research experience.

Applications should be addressed to the Secretary-Treasurer, National Research Council, Ottawa, stating age, race, nationality and giving full details of training and experience.

## Situations Wanted

CHIEF ENGINEER-CONSTRUCTION MANAGER, nineteen years construction maintenance operating, industriel plants, steam and hydro power, canals, water supply, etc., estimates, plans, specifications, supervision of construction. Apply to Box No. 36-W.

**MECHANICAL ENGINEER, B.Sc. Age 31. Married. Last ten years includes:—Mechanical structural and reinforced concrete design in pulp and paper mills, industrial plants, hydro-electric, mine, sewers and sewage disposal plant construction. My experience also includes shop production, steam plant combustion, fuel analysing, inspecting, supervising and instrument work on industrial construction. Permanent position preferred. Apply to Box No. 521-W.**

**DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aero-photographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.**

**DESIGNING ENGINEER AND ESTIMATOR, grad. Univ. of Toronto in C.E., A.M.E.I.C., twenty years experience in structural steel, construction and municipal work. Available at once. Apply to Box No. 613-W.**

ELECTRICAL ENGINEER, B.Sc., E.E., age 38. Married. Ten years electrical experience; including, one year operation, one year maintenance, and four years on construction of hydro-electric plants and sub-stations. Four years electric maintenance and construction in pulp and paper mill Also experience on highway construction and Geological Survey Available at once. Apply to Box No 636-W.

**ELECTRICAL AND CIVIL ENGINEER, B.Sc. Elec. '29, B.Sc. Civil '33. Jr.E.I.C. Age 29. Experience includes four months with Can. Gen. Elec. Co., approximately three years in engineering office of large electrical manufacturing company in Montreal, the last six months of which was spent as commercial engineer. For the last year and a half employed in electrical repair shop. Best of references. Apply to Box No. 693-W.**

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**YOUNG CIVIL ENGINEER, B.Sc. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.**

**MECHANICAL ENGINEER, S.E.I.C., B.A.Sc., Univ. of B.C. '30. Single, age 24. Sixteen months with the Allis-Chalmers Mfg. Co. as student engineer. Experience includes foundry production, erection and operation of steam turbines, erection of hydraulic machinery, and testing texropes and centrifugal pumps. Location immaterial. Available at once. Apply to Box No. 735-W.**

**RADIO AND ELECTRICAL ENGINEER, B.Sc., '31, Jr.E.I.C. Single. Age 29. One year and a half actual field experience in power and lighting equipment. Extensive work in telephone and radio layouts in switchboard and installation depts. Particularly interested and experienced in sales and traffic work in telephone and radio company. At present supervisor over sales and service of radio and electrical company. Available on short notice. Location immaterial. Apply to Box No. 740-W.**

### Employment Service Bureau

Members are again reminded that we are receiving an increasing number of enquiries for engineers.

If you are registered with the Employment Service Bureau please bring your record up-to-date.

The more information you give us, the more intelligently and effectively we can place your record for consideration with prospective employers.

**PLANT ENGINEER or SUPERINTENDENT, capable of supervising all phases of industrial plant operation, graduate electrical, eleven years diversified industrial experience including test course, four years on large Quebec industrial development, on construction and operation, also six years with prominent consulting firm supervising electrical and mechanical engineering projects. Age 31, single. Apply to Box No. 795-W.**

CIVIL ENGINEER, S.E.I.C., B.Sc. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman, compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

STRUCTURAL ENGINEER, B.A.Sc., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

CIVIL ENGINEER, B.A.Sc., Jr.E.I.C., age 32, married. Two years in pulp mills draughting and designing additions, maintenance and plant layout. Three and a half years in the Toronto Building Department, checking and designing for steel, reinforced concrete and ordinary structures. One and a half years as transitman and draughtsman on road location and maintenance work. Available at once. Location immaterial. Apply to Box No. 899-W.

CIVIL ENGINEER, B.A.Sc. (Univ. of Toronto '27). Age 34. Familiar with house building cost, experience combines structural engineering, construction and house building and improvement, interested in obtaining a connection with firms investigating housing problems, making building loans or with a company engaged in construction or building costs. Apply to Box No. 910-W.

**CIVIL ENGINEER, B.Sc., O.P.E. Experience includes several years on municipal work-design and construction of sewers, steel and concrete bridges, watermains and pavements. Available at once. Apply to Box No. 950-W.**

## Situations Wanted

**ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.**

ELECTRICAL ENGINEER AND GEOPHYSICIST. B.Sc. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No. 1168-W.

ELECTRICAL ENGINEER, B.Sc. '34 (Univ. of N.B.), S.E.I.C. Age 21, single. Desires any kind of electrical work. Will consider any location. Apply to Box No. 1262-W.

CIVIL ENGINEER, B.A.Sc. (Toronto '33), S.E.I.C. Married. One year as instrumentman and draughtsman with provincial Highways Dept. One year on grading and reinforced concrete construction with Dept. of National Defence. One year in charge of contractor's branch office on highway paving job. Desire permanent position with opportunity for advancement. Apply to Box No. 1265-W.

CIVIL ENGINEER, M.E.I.C. Married. Age 38. Twenty years experience in organization, design and estimating, and cost accounting. Active service in France. Apply to Box No. 1367-W.

ENGINEER SUPERINTENDENT, A.M.E.I.C., R.P.E., Que. and Alta. Age 47. Married. Twenty years experience as engineer and superintendent in charge of hydro-electric, industrial, railroad, and irrigation construction. Specialized in rock excavation and suction dredging. Intimate knowledge of costs, estimating and organizing. Available immediately. Apply to Box No. 1411-W.

CIVIL AND ELECTRICAL ENGINEER, Univ. of Man. '35 and '36. S.E.I.C. Experience in irrigation and mapping. Available at once. Location immaterial. Box No. 1418-W.

CIVIL ENGINEER, B.Sc. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

SALES ENGINEER, M.E.I.C. Age 50. Married. Several years in combustion and general machinery lines. Estimating and layout work (mechanical and electrical). Speaking French fluently. Executive ability. Apply to Box No. 1482-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.Sc. '31 (Univ. of Alta.), Jr.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work, location immaterial and available at once. Apply to Box No. 1522-W.

CIVIL ENGINEER, B.Sc. '32, S.E.I.C., P.E.N.B., D.L.S.N.B., age 32. Experience in mining, both coal and metals, private and legal surveys, railroad construction, geology and building construction. At present in private practice in coal mining district. Desirous of changing location for position either in mining field or construction in Canada. or abroad. Apply to Box No. 1562-W.

RESIDENT ENGINEER, familiar with all types of surveys and construction work including, railway, roads, irrigation, drainage, buildings and air ports. Executive ability. Had charge of several large projects. Intimate knowledge of reports and estimates. Available immediately. Any location. Apply to Box No. 1567-W.

CIVIL ENGINEER, B.Sc. '17, O.P.E. Married. Executive and administrative experience. Extensive office and field experience in harbour works, dredging; both steam and electric railways in location, construction and maintenance; telephone works in design, construction and maintenance of pole lines, wire, cable and conduit; highways in location, construction and paving; municipal works in roads, sidewalks, sewers and water mains. Intimate knowledge of estimating, unit costs, cost accounting and analysis. Some knowledge of air conditioning. Willing to locate anywhere. Available at once. Apply to Box No. 1587-W.

# Highlights of Research

### A Brief Review of the Work of the National Research Council in 1936.

In the National Research Laboratories at Ottawa the investigations under way have for their main object the promotion of the process of absorption whereby industry and commerce may be improved and expanded through the adoption of the latest and best methods.

The laboratories, employing about one hundred and ninety persons, including scientific, clerical and shop staffs, are organized in five main divisions: agriculture and biology; chemistry; physics and electrical engineering; mechanical engineering including aeronautics; and research information, with which is associated a national scientific library service.

Through its associate committees the Council has continued as in previous years to receive the advice and active support of some hundreds of research workers and technologists in government departments, the universities, and industries. Researches carried out under this system have been productive of good results at a minimum cost to the Council.

Scholarships are granted annually by the National Research Council and in 1936 thirty students, selected from thirteen Canadian universities, benefited under this scheme.

Service to industry is increasing. This consists of the investigation of special problems or the making of tests that cannot be readily carried out in Canadian commercial laboratories. It should be noted, however, that the National Research Laboratories seek to avoid in any way competing with consulting or commercial laboratories in the Dominion. Many problems are brought to the Council from time to time, either by individual companies or by associations that are willing to defray the total cost of the proposed investigations. This is an increasing source of revenue to the Council.

#### Biology and Agriculture

Most of the work now being carried on in the Division of Biology and Agriculture forms part of large co-operative research projects, mainly in collaboration with the Department of Agriculture, but also with the universities and other such organizations.

Food storage and transport depends to a large extent for its success on the proper design and operation of cold storage rooms. A low temperature laboratory, operating at 32 degrees F. and upwards with all the usual laboratory services, has been fitted up. Provision has also been made for quick freezing, using temperatures as low as −40 degrees F. Studies have been initiated to determine the temperature and humidity necessary in the cold store to prevent "freezer burn" or "pock-marking" and encouraging results have been obtained.

Research on malting barley is being carried on and as maltsters ordinarily pay a premium ranging at the present time up to 25 cents a bushel for barley of malting quality, the advantages of this research to producers of barley are obvious.

A most exhaustive survey on peeling of barley kernels during cleaning and handling was completed and reported during the year. It was found that improper threshing was the most important cause of damage.

A co-operative research with the Department of Agriculture is being carried on in crossing wheat and wheat grasses to get large-seeded drought-resistant grass for the dry prairie areas. Partially fertile lines of considerable economic promise have already been produced.

A comprehensive review of the literature on chemical weed killers is being published as a guide to experimental research in this field.

#### Chemistry

At present the Division of Chemistry has an organized relationship for research with the laundering and dry cleaning industry, the asbestos industry, the manufacture of basic refractories, and to a slighter extent the wool manufacturing and sugar industries.

In recent years Canada's buffalo herds have increased very considerably in numbers and it has been necessary to slaughter large numbers of the animals each year. About fifteen hundred buffalo hides are now available annually from them. As the ordinary methods of treating the buffalo skins were not satisfactory, experimental work was undertaken both in the tanning and later in the dyeing of buffalo hides. Preliminary studies have also been undertaken on the treatment of reindeer hides and on Canadian sources of tannin.

In an investigation undertaken with the object of promoting the utilization of Canadian deposits of magnesian rock, success has been attained in the production of a stable refractory from dolomite and other cheap and widely available raw materials. This investigation has also resulted during the year in (1) the perfection of a method of manufacturing a strong unburned basic brick; (2) major improvements in the quality of refractories bonded with sodium silicate; (3) development of a method of increasing the plasticity and workability of refractory cements; and (4) production of a greatly improved refractory with hydraulic bond.

Success has been attained in modifying potato starch so as to obtain from it results in culinary products similar to those given by standard corn starch.

Paints, varnishes and enamels are under study in the laboratories to determine their behaviour under Canadian climatic conditions and on various Canadian woods.

Fundamental work has been undertaken on the composition of the soya bean to determine the distribution of oil, proteins, phosphatides, etc., in the commercial products prepared from this material. Soya beans are now being produced in Canada on a small but increasing scale.

An extremely efficient distillation column was built in the laboratories during the year and may also be applicable in the production of gasoline with such superlative anti-knock qualities as to enable aeroplanes to make longer journeys on a given load of gasoline.

#### Mechanical Engineering

The Division of Mechanical Engineering includes the aeronautical laboratories, and during the year the snow resistance of aircraft skis was thoroughly investigated. It was found that most of this resistance is due to solid rubbing friction and that the shape of the ski is of secondary importance. By treating the surface of a wooden ski with a suitable wax preparation the resistance to friction was greatly reduced, and a much better performance could be obtained from wooden skis so treated than from any metal surface.

At the request of the Department of National Defence a study is being made of the stalling of heavily tapered wings as used on modern aircraft.

As part of a study of stressed skin construction, as used in modern aircraft, strength tests are being made of full scale aircraft floats under the two conditions of loading corresponding to the so-called two-wave condition and the bow-landing condition.

Work is proceeding on the design of a windmill that will operate in light winds and thus be suitable for use in the development of electric power on farms.

In the model-testing basin work was completed during the year on models for two 120-foot. twin Diesel patrol boats for the Royal Canadian Mounted Police.

#### Physics and Engineering

In co-operation with the Canadian National Railways the Council has developed a new heating system for refrigerator-type cars in which perishable goods are shipped during winter months.

Aerial photography holds an important place in map making. In converting the photographed information into a map, it is necessary to correlate the series of photographs, and this is done by taking advantage of the principles of perspective projection. The usual practice has been to employ a hand graphical method, but now a machine has been developed under the auspices of the Surveys Research Committee and constructed in the National Research Laboratories whereby the operation can be carried out mechanically, with greater accuracy and speed.

It has been found that the results obtained by research laboratories in testing the sound absorption values of wallboards vary considerably, and an investigation has been undertaken to determine the best methods of making these measurements.

The accuracy now attained in practical gauges used in engineering is such that the primary standards of length from which these gauges are derived must frequently be known to one-millionth of an inch. Apparatus has now been installed in the laboratories that permits limited measurements to be made in terms of light waves.

Radio methods in weather forecasting are being investigated. For this purpose a cathode ray direction finder, constructed in the laboratories, was installed at Forrest, Manitoba, with the co-operation and assistance of the Civil Aviation Branch of the Department of Transport. A similar station has been installed in Ottawa with the help of the Canadian Broadcasting Corporation. Sources of static appear to be intimately related to weather conditions.

Apparatus was set up recently for X-ray crystal analysis for the purpose of making many investigations in the laboratories.

It has been found in Germany and England that the electrical stunning of hogs before killing reduces the difficulty of handling. It was suggested by the Department of Agriculture that this principle might be applied to poultry with a view to obtaining better feather release and improved bleeding.

Demands from within the laboratories for precisely regulated voltage in connection with work on X-rays, heat conductivity tests, light tests on incandescent lamps, etc., prompted the development fo a precise voltage regulator. The significance is seen in that a change of one per cent in the applied voltage will affect the life of a lamp by 14 per cent. The principle employed in this regulator has also been adapted to the speed control of electric motors.

Assistance has been given the colour and printing trade in the development of a daylight recorder whereby the grading of colours for fastness can be placed on a scientific basis. Another development was the installation of a very fine three-meter concave grating with 30,000 lines to the inch for spectroscopic work in the analysis of minerals, alloys and the detection of small quantities of impurities in substances.

#### Division of Research Information

This division serves the laboratory workers by searching the scientific literature for references to previous work on any projected research. A library service is maintained; translations within certain limits are made as required; secretarial and other necessary services are provided for the associate committees, and, in general, a liaison is maintained between the laboratories and the public.

# THE ENGINEERING JOURNAL

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## CONTENTS




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# The British Grid System

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**Paper to be presented before the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—The author describes the way in which the Central Electricity Board has co-ordinated the operations of the many local supply systems in Great Britain, establishing a national system of high-voltage transmission lines, controlling the generating stations feeding the network, and supplying energy in bulk to the various distributing authorities.

The Semicentennial of The Engineering Institute of Canada is an event of particular interest to engineers. Your Society, while not so old as the British Institution of Civil Engineers (which, founded in 1818, is the doyen of our professional institutions), is in one sense older than the British Institution of Electrical Engineers, for though the Society of Telegraph Engineers was founded in 1871, it did not become the Institution of Electrical Engineers until 1888.

Faraday's fundamental discovery of induction goes back more than a century, but the whole technique of modern large-scale electricity distribution is dependent on alternating current practice—and alternating current technology was only in its infancy when your Institute was established. It is difficult to imagine that electricity supply could have reached its present position without high-pressure alternating current transmission. The history of your Institute therefore covers the whole period during which, in all the principal countries of the world, the distribution of electricity has grown to the dimensions of an industry of primary national importance—a public service as vital as water supply or sanitation.

The problems of power supply differ widely from country to country, but the differences are more in detail than in the central objective of the supply industry, which is the same everywhere—to meet the ever-growing need of the community for economical and reliable electrical service.

This paper is presented in the hope that some account of the problems confronting the supply industry in the Mother Country, and of the methods adopted in their solution, will be of interest and service to those who have similar problems on the much wider geographical scale of the great Dominion of Canada. The paper is particularly appropriate on this occasion, for 1937, the fiftieth anniversary of your Institute, is ten years after the date when the Central Electricity Board of Great Britain was first established.

### Public Supply in Great Britain Prior to the Grid

Any problem needs to be viewed in perspective against its natural background—in this case the environment and development of the supply industry. To do this we must go back a long way, for like most British institutions the Grid has its roots in history.

The basic unit in British local administration is the Parish, which was the zone of influence of a single place of worship when religion dominated community life in the Middle Ages. Rural districts, urban districts and boroughs have been built up by the aggregation of parishes, and national parliamentary representation is still organized on that fundamental unit. As a consequence, in spite of at least a century of reforms, revisions and amalgamations, there are still over two thousand separate authorities responsible for local community organization.

Up to the middle of the 18th century, the population of Great Britain was fairly evenly distributed over the country in farming villages surrounding small market towns, each village and town having its own parish church. In these conditions administration on a parochial basis was natural and logical. But the coming of the Industrial Revolution and the opening up of the great grain-producing areas of the Dominions brought a vital change. Farming communities dwindled at the calls of emigration and industry. Steam brought the industrial age, and steam meant coal to be won and used. Developing world trade meant the building of docks and harbours on the estuaries which are Britain's natural arteries of commerce, and the construction of an intricate network of roads and railways. Population followed these developments, huddling into the coalfields and along the larger estuaries and creating huge urban agglomerations.

Crowded urban centres brought in their train new problems in public health, and the various types of local authority were the natural media for the work of providing essentially local services such as drainage, sanitation, and road maintenance. Legal powers obtained for these purposes gave local authorities a commanding position when public water and gas supply came into question, and although these services were in some instances first provided by private enterprise, they are largely in the hands of local authorities.

None the less, the participation of private enterprise in connection with water and gas was substantial, and the conflict of interest between the bodies concerned in road maintenance, drainage, sewage disposal, water and gas supply became so acute that Parliament was obliged to devote a great deal of its time to elaborating various forms of regulative legislation.

It was into this atmosphere that the electricity supply industry was born.

The first public supply of electricity in Great Britain was given in 1881. All the essential basic discoveries had of course been made many years earlier. Electricity had been transmitted by wire nearly one hundred and eighty years before. In 1812 Davy's arc lamp had shown the applicability of the new force to lighting, and 1881 was the semi-centenary of Faraday's fundamental discovery of induction.

The first parliamentary enactment dealing with public electricity supply—the Electric Lighting Act of 1882—while providing for both local authority and company ownership, contained provision for the compulsory purchase of company systems by the local authority after a period of twenty-one years, at the then market value of the physical assets without regard to goodwill or profits. This limitation on tenure, coupled with purchase terms which would obviously militate against expansion, was a deterrent to private enterprise, and in 1888 a further Act doubled the period of tenure.

Early legislation thus clearly favoured supply by a local council—and there were over two thousand such bodies. The more powerful, wealthy and progressive of these were of course to be found in the rapidly-growing urban centres, and not in the shrinking rural communities. The earlier act had given power to local councils to contract with private concerns to provide and maintain electricity works, and this type of business absorbed the attention of most of the pioneer companies; where a company desired to obtain powers itself, it was obviously easier to negotiate with a single local authority than to apply for powers over a wider area. On the technical side, private lighting had started with 110-volt direct-current belt-driven dynamos and batteries. The earlier public distribution systems were merely enlargements of this prototype, and therefore had a very limited range of operation.

All factors therefore favoured the setting up of a large number of small generating stations, designed to supply only in their immediate vicinity, towns alone being served, to the almost complete neglect of country districts. Further, with electrical science still in its infancy, the inventive skill of the pioneers produced a wide variety of systems. The alternator had actually been invented in 1878, but direct current started with an initial advantage in practical application. Although the work of Ferranti demonstrated the potentialities of alternating current transmission, the small distribution areas resulting from the early legislation, the abundant supply and wide geographical distribution of coal and the absence of substantial waterpower resources, gave at that stage no such incentive in favour of alternating current as existed in other countries.

When alternating current began to make headway, lighting was still the chief load to be considered, and one and two phase systems were at first adopted, with a variety of frequencies. With small scale independent systems mainly supplying local lighting loads, such variations were perhaps not of major importance. But industry began to turn to the new source of power, so much more flexible than reciprocating engines and mechanical drives, and small scale public generation offered no attractions to the industrialist accustomed by the steam age to regard provision of his power requirements as an integral part of his manufacturing process. Experience in the Dominions and elsewhere was already showing the advantages of large scale production coupled with high voltage transmission, but in Great Britain the early legislation had made the logical corollary of larger supply areas impracticable, first by the limited tenure system, which would have rendered small sections of any comprehensive distribution network liable to purchase by local councils at various differing dates, and secondly by the prohibition of amalgamation and coordination.

It was clear that the supply industry was outgrowing its early legislative clothing. In 1898 a number of special Bills were promoted in Parliament, so far-reaching in their proposals that a Parliamentary Joint Committee presided over by Lord Cross was appointed to deal with them. As a result of that committee's recommendations, ensuing years saw the establishment of a number of "power companies" differing from the earlier distributing companies in that they operate under special individual acts giving perpetual franchise, and the right to supply over wide areas, mainly for industrial power and traction purposes and for bulk sale to distributing authorities. In areas covered by such "power" acts, however, the interests of existing local authority distributors were safeguarded by rights of veto on supply by the power companies within their borders, and since the existing local authority areas naturally consisted of those parts most ripe for development complete co-ordination was impracticable.

The power company legislation tacitly conceded the principle that the economic unit for electricity purposes was much larger than the local administrative boundaries. In 1909 a further general act made it possible for neighbouring distributors to give and take bulk supplies and establish transmission lines for that purpose, but up to the outbreak of the Great War in 1914, development was mainly along the lines of isolated systems with individual small scale generation and relatively little interconnection. As will be seen from Table I, supply powers were very largely confined to the urban centres.

Table I

Percentages of Total Area and Population of Great Britain Covered by General Supply Powers

| Year | Area | | Population | |
|---|---|---|---|---|
| | Urban | Rural | Urban | Rural |
| 1891 | 8.0 | 0.1 | 22.6 | 0.1 |
| 1901 | 31.9 | .5 | 67.5 | 1.6 |
| 1911 | 46.3 | 5.0 | 80.1 | 16.7 |
| 1921 | 57.6 | 7.0 | 88.1 | 22.4 |
| 1926 | Passing of Electricity (Supply) Act, 1926. | | | |
| 1931 | 96.8 | 63.3 | 99.0 | 84.1 |
| 1937 | 99.8 | 85.8 | 99.9 | 94.8 |

Manufacturing industry continued to rely mainly on its highly-developed individual steam-power equipment, and public supply development was hampered by the bewildering variety of voltages, frequencies, generation and distribution systems, and methods of charge, which had gradually accumulated. In Greater London, for example, even in 1921 there were some eighty separate supply authorities, seventy generating stations, fifty different systems of supply, twenty-four different voltages and ten different frequencies. The multiplicity of technical systems had involved manufacturers in duplication of patterns, types and stocks, and thus deprived them of the advantages, both in home and foreign markets, which would have derived from concentration of production on a few standard types.

The War at last focussed attention to the long felt need for reform. The demand for war material brought with it an unprecedented change in the direction of industrial effort, at a time of acute strain on manpower resources. Steam power industrial equipment proved to be relatively inflexible, and in four years the load on public electricity supply systems was more than doubled. It came to be recognized that lack of co-ordination in public supply had re-acted adversely on the application of electricity to industrial power purposes and had resulted in unnecessary expenditure of capital, unduly high fuel consumption and consequently higher charges to the consumer than those which would have ruled with larger supply areas, larger generating units, and more economically situated generating stations.

The need for re-organization was so obvious that even during the War three successive governmental Committees were set up to consider various aspects of the situation. In 1919 the first step in the development of a comprehensive system of generation, transmission and distribution was taken. An act was passed which further facilitated interconnection, transferred the supervisory powers previously vested in other government departments to the newly-formed Ministry of Transport, and established under that Ministry a new administrative body, the Electricity Commissioners. This body was charged with control over the erection and extension of generating stations and transmission lines, and given the duty of initiating schemes for the voluntary establishment of regional co-ordinating authorities with the object of interlinking the existing systems and unifying both production and distribution over the whole region. The act, however, did not make the establishment of such authorities compulsory, and although the Electricity Commissioners duly initiated a number of such schemes, the divergence of interest between local authority and company distributors was too great to be bridged by voluntary schemes, and only three Joint Authorities were actually established.

By 1925 it had become clear that more drastic measures were necessary, and a further Government Committee, under the chairmanship of Lord Weir, was set up to reconsider the whole situation. That Committee's recommendations constituted the basis upon which the reorganization of generation and main transmission in Great Britain has been carried out, and it is interesting to see the state of the industry at the time of their deliberations.

The area of England, Scotland and Wales is 88,141 square miles, and at the 1921 census it had a population of 42,769,000, of which 33,346,000 were in urban areas and only 9,423,000 in rural districts. As will be seen from Table I, 88 per cent of the urban and only 22 per cent of the rural population were then covered by supply powers. Only minor extensions took place between then and 1925, and yet, in the latter year, there were 338 public authorities and 225 companies holding supply powers, and a total of 539 separate systems actually giving supplies. No less than 301 of these systems relied entirely on their own individual generating stations, a further 119 supplemented local generation by a partial bulk supply, and only the remaining 119 depended entirely on bulk supply. Table II summarizes the position as it existed when the Weir Committee was appointed:—

Table II
State of British Supply Industry in 1924-5

Population Served

| Total Population of Supply Area | No. of Systems |
|---|---|
| 500,000 and over | 17 |
| 100,000 and under 500,000 | 84 |
| 50,000 and under 100,000 | 71 |
| 10,000 and under 50,000 | 229 |
| Under 10.000 | 123 |
| | 524 |

Electricity Sold

| Millions of Units Sold to Consumers | No. of Systems |
|---|---|
| 100 and over | 9 |
| 50 and under 100 | 17 |
| 10 and under 50 | 84 |
| 1 and under 10 | 172 |
| Under 1 | 246 |
| | 528 |

Size of Generating Stations

| Total Installed Capacity (Megawatts) | No. of Stations |
|---|---|
| 100 and over | 1 |
| 50 and under 100 | 12 |
| 10 and under 50 | 96 |
| 1 and under 10 | 178 |
| Under 1 | 207 |
| | 494* |

*Average capacity = 7.54 megawatts (mw.)

Average Fuel Consumption at Steam Stations

| Lb. of Fuel per Unit Generated | No. of Stations |
|---|---|
| Under 2 | 8 |
| 2 and under 3 | 87 |
| 3 and under 5 | 112 |
| 5 and under 10 | 63 |
| 10 and over | 20 |
| | 280 |

Combined returns in certain cases affect the comparability of the totals given in this table; this applies particularly to the numbers of steam stations. The figures are striking evidence of the relatively small scale of operation which characterized the industry at that time. The medley of systems then employed is amply demonstrated by the figures in Table III:—

Table III
Supply Systems in Use in Great Britain in 1924-5

Types of Supply Afforded

| Current | No. of Systems |
|---|---|
| A.c. only | 145 |
| Both a.c. and d.c. | 203 |
| D.c. only | 191 |
| | 539 |

A.C. Frequencies Employed

| Cycles | No. of Systems |
|---|---|
| 25 per sec. | 26 |
| 40 per sec. | 21 |
| 50 per sec. | 288* |
| 60 per sec. | 7 |
| 100 per sec. | 11 |
| All others | 15 |
| | 368† |

*Includes 252 employing 3-phase and 36 using 1 or 2 phase only.
†Systems employing more than one frequency have been counted under each frequency.

The retarding influence of these factors on the electrification of British manufacturing industry can be judged from Table IV:—

Table IV
Power Equipment of British Industries in 1924

| Type | Horsepower | Per cent of total power |
|---|---|---|
| Mechanically applied | 7,203,900 | 48.3 |
| Electric motors driven by generators at works | 3,516,400 | 23.6 |
| Electric motors driven by purchased electricity | 4,197,100 | 28.1 |
| Totals | 14,917,400 | 100.0 |

### Reasons for Adoption of Grid Policy

Although these figures rather present a picture of chaos, it is not suggested that the supply industry was inefficient. In the five years from 1920 to 1925, the national average fuel consumption at all steam-driven public generating stations was brought down from over 3.3 lb. of coal per unit generated to 2.4 lb. In the same period, many of the larger generating stations which are now linked up with the Grid were built by the more important supply authorities, while there was a steady lowering of price to the consumer, expansion of supply areas, and extension of distribution systems.

But experience was indicating that nation-wide interconnection was not only practicable but was necessary to an effective solution of our problems. Even if the voluntary co-ordination proposals had not broken down, they would have been only a palliative. To give but one reason, important areas of the country had been developed at 25


Fig. 1—Main "Grid" Transmission Lines.

and 40 cycles, and a system of co-ordination by regions would almost certainly have perpetuated those two frequencies. Standardization was essentially a national problem.

The problem set before the Weir Committee, therefore, was to review the whole national problem of the supply of electrical energy. Its task was not an enviable one. Voluntary schemes of co-ordination had broken down, and some measure of compulsion was inevitable.

After hearing a wide variety of evidence, from both British and overseas witnesses, the committee came to the conclusion that there was a natural line of cleavage between production and distribution, and that retail distribution was a local matter, which might well be suitable for decentralization. On the production side, however, they considered it necessary to treat the whole country as one unit, the experience of other countries being conclusive evidence in favour of concentrating production into a relatively small number of large and efficient stations, interconnected by a national system of main transmission lines. Such a plan would entail standardization of frequency, and the rapidity with which industrial demand was growing made the re-organization of production and main transmission a matter of urgency. They recommended that a central authority should be set up with compulsory powers to construct and operate a national system of trunk mains and to control the generating stations feeding into it.

The findings of the Weir Committee were the basis of the Electricity (Supply) Act of 1926.

### Main Features of the 1926 Act

That act started out by creating a new type of administrative organization. The Central Electricity Board consists of an executive chairman and seven members, all of whom are appointed by the Ministry of Transport after consultation with the bodies concerned with local government, electricity, commerce, industry, transport, agriculture and labour, but are not formally representative of or appointed by such interests. They are appointed for not less then five or more than ten years, and are eligible for re-appointment at the end of their term of service. Although appointed by the Minister of Transport, and presenting annual reports and accounts to him, the Board is in no sense a government department. So far as such matters as the raising of capital, the standards of construction, and the routes of transmission lines are concerned, the Board is subject to the same regulation and control by the Minister of Transport and the Electricity Commissioners as any other body holding statutory powers for the supply of electricity. Otherwise the Board has complete freedom from political control, and no Member of Parliament is allowed to serve thereon. It is in short a business corporation, given a maximum measure of independence in its policy and administration; it is required to be financially self-supporting, but is not allowed to make any profits.

The Central Electricity Board was given power to decide what standardization of frequency was necessary to the re-organization, and to require the non-standard systems concerned to be converted by their owners to the 50-cycle basis adopted as the British standard. The capital for the purpose was to be advanced by the Board, who should be recouped for the interest and sinking fund charges on the money so advanced by a levy on all distributing authorities proportionate to their revenue from the sale of electricity. The adoption of a forty-year basis for the sinking fund ensures the spreading of the cost of standardization over a period reasonably related to the benefits, which will only accrue gradually and must to some extent be dependent on the growth of output.

The act next provided that the Grid itself should be constructed and operated by the Central Electricity Board, the capital required both for that purpose and for standardization of frequency being raised by public issues of fixed interest bearing redeemable stock.

The existing efficient stations to be used in conjunction with the Grid remain in their original ownership, but their operation is directed by, and their whole output sold to, the Central Electricity Board at the actual cost of production, the items of expenditure in that cost being specified. Capital charges include, in the case of local authorities (which normally raise capital by fixed interest bearing stock) the actual interest and sinking fund charges attributable to the capital expenditure on generation account. In the case of companies, interest is included at a minimum of 5 and a maximum of 6½ per cent on the money expended as generation capital, while depreciation is allowed on a prescribed scale.

The Board is to direct the operations of the stations connected to the system in such a manner as to produce the best results for the system as a whole and is to sell electricity in bulk to the distributing authorities. The act provides that the Board's tariffs shall contain a fixed kilowatt charge and a running charge, these charges being calculated to cover the estimated revenue expenditure, including interest and sinking fund charges, with such margin as the Electricity Commissioners may allow, the whole being equated over a period of years. This equating of charges makes some of the benefits of the scheme available from the outset, since the demand for electricity may be anticipated to grow fairly rapidly and therefore the fixed charges will be spread over a larger volume of sales in the later years. To the same end, the Central Electricity Board is empowered to charge interest to capital account in the preliminary period and to suspend sinking fund payments for a limited number of years.

The general recommendation of the Weir Committee was that production of electricity should be concentrated into the more efficient stations (designated "Selected" stations) and that the less efficient stations should be closed down, but the 1926 Act contains safeguards designed to ensure that no distributing authority is placed in a worse position by the establishment of the "Grid." It provides that no non-selected generating station can be closed down compulsorily unless the Board shows that the cost of supply on their standard terms will for a period of not less than seven years be lower than the existing cost of local generation excluding such capital charges as would continue if the station were closed down.

A somewhat similar safeguard is given to the owners of selected stations. The act contemplates in general that selected station owners will purchase so much of their requirements as is produced at their own station or stations at the actual cost of production adjusted to the load factor of their own supply, with the addition of a due proportion of the charges associated with the Grid, or at the Board's

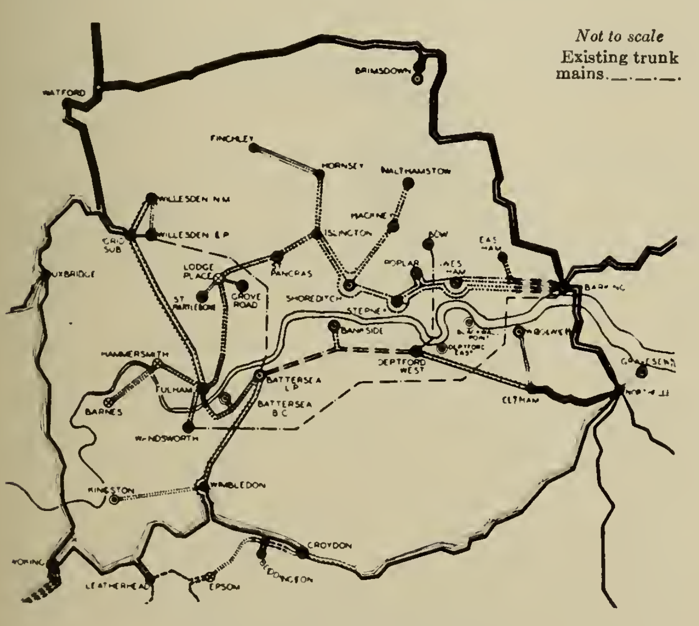


**Fig. 1a—London Cable Grid.**

general tariff if that proves more favourable, with an over-riding protection that in any event they shall not be charged more for their supply than the costs they would have had to face under conditions of completely independent operation.

### The Establishment of the Central Electricity Board

Following the passing of the 1926 Act, which received the Royal Assent in December of that year, the Central Electricity Board was set up in March, 1927, its first chairman being Sir Andrew Duncan, who will be remembered by Canadians for his chairmanship of the Nova Scotia Coal Mines Commissions of 1925 and 1932 and the Maritime Claims Commission of 1926. Sir Andrew is still a member of the Board, but on his appointment as Executive Chairman of the British Iron and Steel Federation, Sir Archibald Page was appointed Chairman of the Board.

To facilitate the work of the Board, the act provided that Great Britain should be divided into a number of regional scheme areas, which the Electricity Commissioners were to define and for each of which they were to prepare a technical scheme setting out the stations to be selected, the sections of the national transmission network to be built and the standardization of frequency to be effected. Each of the schemes when received by the Board was published and opinions thereon invited from all interested parties. The Board, after making such changes as were deemed desirable, proceeded to adopt the schemes, to work out in detail the technical arrangements necessary and to arrange for the constructional work and the standardization of frequency involved. The act further laid down a period, after the adoption of each scheme, within which any supply authority upon whom obligations were laid, and who felt prejudiced thereby, might appeal to arbitration. It says much for the soundness of the initial plans, and for the conciliatory policy of the Board, that in no instance was recourse to arbitration found necessary.

Nine schemes (Central Scotland, South East England, North West England and North Wales, Central England, Mid-East England, East England, North East England, South West England and South Wales, and South Scotland) were adopted between 1927 and 1932, covering the whole of Great Britain except North Scotland, which consists mainly of sparsely-populated mountainous country (the whole area of over 20,500 square miles contains under 2 per cent of the national population) and for which no scheme is in immediate contemplation. The general geographical layout of the system is shown in the accompanying map (Fig. 1).

### Technical Features of the Grid

High voltage transmission is now long established practice, but in countries other than Great Britain is mainly used for transmitting large quantities of power from sources of energy remote from population centres to principal consuming points. In Great Britain, where the sources of energy are comparatively close to each other and where generating stations are mainly located at or in close proximity to consuming centres, the function of the high voltage system is not the one-way transmission of large blocks of power, but the interconnection of power plants so as

(*a*) to raise plant utilization factors by reducing the amount of reserve generating plant required in individual stations, and
(*b*) to secure the highest practicable load factor on the most efficient plant in the system.

The system may be likened to a magnified set of sectionalized bus-bars to which all the generating plant is connected and from which all the main feeders are run. Interconnection of power stations for such purposes had, of course, already been carried out in other countries on a comparatively large scale, and, indeed, had been used to a limited extent by the power companies in Great Britain.

The novelty of the Grid scheme lies in the application of these principles on a national scale, involving the construction of a high-voltage system of considerable magnitude and the parallel operation of a large number of individual power plants.

The physical layout of the British system was of course largely determined by the geographical location of the efficient generating stations existing at the time it was established. Since those stations were situated at or near the principal centres of demand, the interconnection of the stations automatically provided a plan adjusted to existing load conditions, while the connecting lines could in future be tapped if new centres of load grew up. For example, in planning the system due regard was had to the potential demand which might arise if extensive main-line railway electrification were undertaken.

The general principle followed in the layout of the Grid is that all important load centres should be served by two separate Grid links. The system therefore consists of a number of rings, connected by tie lines to neighbouring rings, and is designed for 3-phase operation at 132 kv. between phases, this voltage being chosen as the most economical for the load requirements and transmission distances encountered in Great Britain. It was also the highest voltage for which the design of underground cables was then reasonably well developed.

The main 132 kv. Grid system serves as a feeder for extensive lower voltage (mainly 66 and 33 kv.) systems supplying undertakings whose load requirements are insufficient to justify direct connection to the main Grid.

The 132 kv. system is designed for operation with all neutral points directly earthed, for the following reasons:—

First, multiple earthing would be the least objectionable from the standpoint of inductive interference with communication systems.

Secondly, considerable economies would be effected by the use of transformers with graded insulation.

Thirdly, discriminative protective equipment could be simplified.

Fourthly, maximum phase potential to earth would be limited.

There are now 2,898 route miles of 132 kv. lines, 1,227 route miles of 66 kv. and lower voltage lines, and 289 transforming and switching stations, with an aggregate transforming capacity of 9,475 mva. (megavolt-amperes).

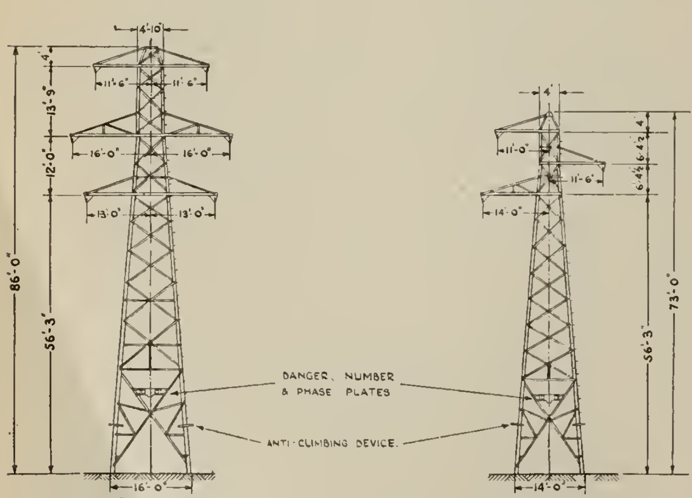


Fig. 2—Typical 132-kv. Towers.

*Overhead Lines*

The lines comply with the regulations of the Electricity Commissioners, but factors of safety were adopted somewhat in excess of those strictly required. Steel-cored aluminium conductors were chosen for practically all the Grid lines, a major reason for this choice being the difficulty, in a densely-populated country such as Great Britain, of obtaining wayleaves for tower positions, which made imperative the use of long spans.

The standard 132 kv. conductor consists of a central core of 7 strands of galvanized steel wire each 0.11 in. diameter, surrounded by 30 strands of aluminium wire of the same diameter in two layers. Conductivity is equivalent to that of a copper conductor of 0.175 sq. in. cross sectional wire. The overall diameter is 0.77 in. The nominal capacity per 132 kv. circuit is 50 mva.

A continuous earth conductor is attached to the apex of all towers. The earth conductor consists of a 7-strand

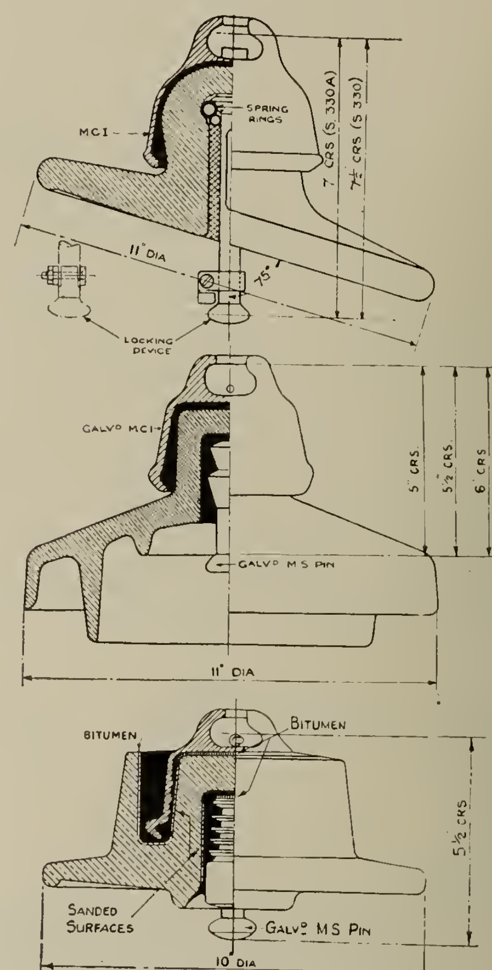


Fig. 3—Anti-Fog Type Insulators.

steel core covered by 12 strands of aluminium in a single layer. All strands are 0.11 in. diameter. The steel core is protected against corrosion by bitumenizing.

*Towers*

The standard Grid towers are all of the broad base lattice steel type with phase conductors in triangular formation on single circuit lines and hexagonal formation on double circuit lines. The broad base type was chosen mainly for economic reasons, but aesthetic considerations played a considerable part in the choice. A horizontal arrangement of conductors has much to commend it from the engineering point of view, but was ruled out by economic considerations.

Mild steel is normally used for the towers, protected against corrosion by galvanizing. In the Central England Area, however, ungalvanized painted copper-bearing steel was adopted. Foundations of the excavated earth, concrete block and concrete ball type have been used, the particular type chosen depending on the nature of the subsoil. Figure 2 shows the general design adopted for standard single and double circuit towers.

*Insulators*

Suspension insulators of the cap and pin type with ball and socket fittings have been standardized. Ninety per cent of the units are of the general form used in Canada and elsewhere, but the remaining 10 per cent. are special anti-fog types. Certain areas of Great Britain are notorious for the prevalence of fog and industrial atmospheric pollution. In these areas the anti-fog insulators have been effective in improving the degree of immunity of the lines from fog flashover. Figure 3 shows the three types which have been used.

*Switching Stations*

The majority of the transforming stations have two incoming lines and two transformers, controlled by three 132 kv. circuit breakers. Figure 4 shows that one circuit-breaker acts as a section switch between the two incoming Grid lines, while the two others are in the transformer primary connections. In cases where more than two lines or two transformers have to be controlled, the switching arrangements are of the busbar or mesh types. An example of the mesh type station is illustrated in Fig. 5. In cases where extreme economy was necessary, the switching arrangements were simplified and the circuit-breakers were omitted from the transformer primary circuits. In one case all supplies are delivered to the Grid from a large selected generating station through transformer feeders without the intervention of higher voltage switchgear. The outstanding feature of the Grid switching arrangements has been the keeping of the number of circuit-breakers to the absolute minimum necessary for safe operation, which has effected great economies in construction as compared with similar high power and high voltage interconnected networks elsewhere.

The physical layout of the switching equipment naturally varies in accordance with the site facilities available. Where the requisite ground area has been available low type switching stations are used, high type stations being adopted only where ground area is restricted.

*Transformers*

With the exception of a few banks of single-phase units, all transformers are of the 3-phase type, provided with on-load ratio-changing equipment fitted to the high voltage windings. The lower voltage is in accordance with the requirements of the individual undertakings, and varies from 3.3 to 66 kv. The capacities of the 132 kv. units range from 3 to 75 mva., an example of the latter being shown in Fig. 6. All transformers were designed for transport over the British railway systems, which have a somewhat restricted loading gauge. Transformers of 10 mva. and below have natural cooling, but in exceptional cases natural cooling has been used on 20 mva. units. Large transformers have natural cooling up to approximately half load, and at higher loads have forced air-blast cooling and forced oil circulation. It was a primary requirement that all transformers should operate as silently as possible.

132 and 66 kv. windings are star-connected, and the lower voltage windings delta-connected. All 132 kv. transformers have a voltage regulating range of ± 10 per cent. The lower voltage transformers are of the same general type as the 132 kv. but the phase arrangements and voltage regulation range are varied to meet local requirements.

Probably the most noteworthy feature in the Grid transformers is the wholesale adoption of on-load ratio-changing equipment. This step, which was a somewhat bold one, in view of the small amount of development of such gear prior to the construction of the Grid, has proved to be eminently satisfactory.

*Protective Gear—Selective Protection*

British power systems prior to the Grid were on a comparatively small scale. Where exact selective protection equipment was essential, this was provided by balanced pilot wire equipment. Owing to the prohibitive cost which would have been involved in providing highly insulated pilot wires for the whole of the Grid system, it was necessary to design a protective scheme of a less costly nature but giving similar performance.

Underground cables and line sections less than 10 miles long have pilot protection either of the balanced type using normal pilots or of the interlock type using pilots

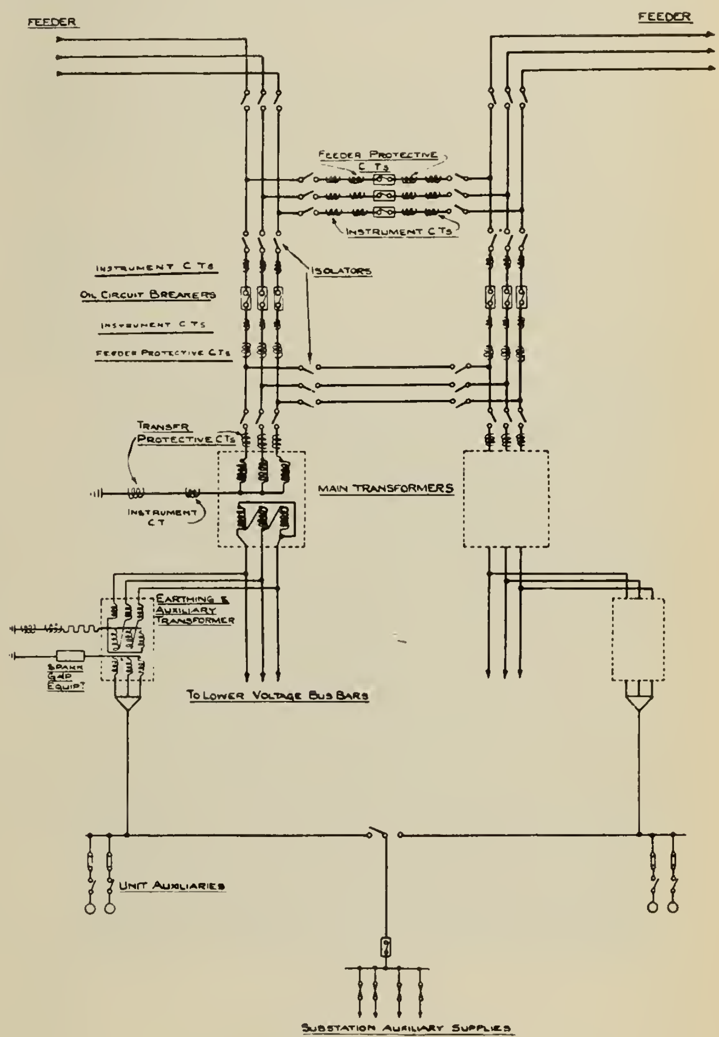


**Fig. 4—Typical Three-Switch Substation.**

hired from the communication authorities. Longer sections have distance protection of the ratio balance or impedance type. Certain sections connected to the system through transformers only are protected by earth leakage and overload gear. All main transformers have balanced discriminative earth leakage protection.

*Metering*

The provisions of the 1926 Act entail metering equipment of a special nature. At each selected station, it is necessary to make the following measurements of both kilowatts and kilowatt hours:—

(1) The output of the generators.
(2) The export from the station to the Grid.
(3) The import from the Grid to the station.
(4) The consumption of the local undertaking.

To make this last mentioned measurement, it is necessary with both power and energy to add imports to generation and subtract exports. To reduce clerical computations to a minimum, special high accuracy summating systems were evolved to do this. Special long-scale indicators were introduced to measure the maximum demand with high accuracy, and printometers were developed to give a permanent half-hourly record of the principal maximum demands, namely, the undertaking's requirements, the generators and the import. Reactive component metering had also to be installed to provide the power factor measurements required by the act.

An example of a typical selected-station metering equipment is illustrated in Fig. 7.

*Special Constructions*

More detailed technical information than can be given in this necessarily brief outline is contained in the papers mentioned in the bibliography. Of the special constructional features of the Grid, space only permits the mention of two, but many of them, although only details in the general plan, are in themselves major engineering works.

In the overhead lines the river crossings are all of considerable interest. The Thames crossing at Dagenham—the highest river crossing in the world—is shown in Fig. 8. It is now a landmark which is familiar to all approaching England by way of the Thames. In switchgear the most striking example of a pioneering all British development is the 132-kv. metalclad installation at Tongland which is shown in Fig. 9.

*Cables*

The great extent of the Grid overhead line system tends to overshadow the cable sections. It is however important to note that in Central London and in the connections between the Central London System and the Outer Grid, underground cables had to be used. The London Grid cable system is shown in Fig. 1a. It comprises 42.5 route miles of 66 kv. cable and 23.6 route miles of 132 kv. cable. The oil-filled cable so far holds the field for voltages of the order of 132 kv. and above, but the Board has also assisted in the development of other types of cable which promise to eliminate the disadvantages associated with oil-filled cable. A 2½ mile section of 3-phase 66 kv. cable of the external nitrogen pressure type has been in commercial service between Hackney and Walthamstow since 1932, and an experimental one-mile length of 132 kv. internal pressure nitrogen cable will shortly be installed at Wimbledon.

*Control*

For control purposes the Grid is directed from seven control centres situated at Glasgow, Newcastle, Leeds, Manchester, Birmingham, Bristol and London. General particulars of the systems are set out in Table V—the largest of these systems is that controlled from London,

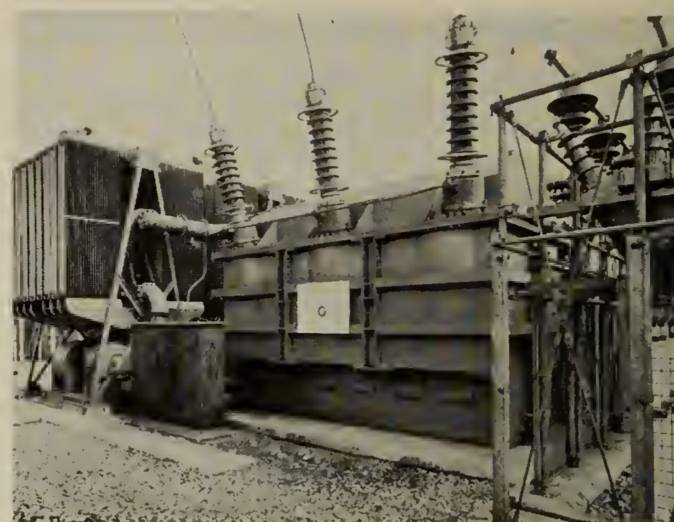

**Fig. 6—75 mva. Three-Phase Transformer compared with Faraday's Induction Ring.**

the present capacity of the generating plant directed from that centre being about 2,000 mw.

The communication circuits are hired from the British Post Office, the majority being in underground cables.

With the exception of a few omnibus circuits serving two stations where traffic is light, separate circuits are provided between the control centre and each main grid point. Stations on the lower voltage secondary lines are served by extension omnibus circuits from the parent grid point concerned.

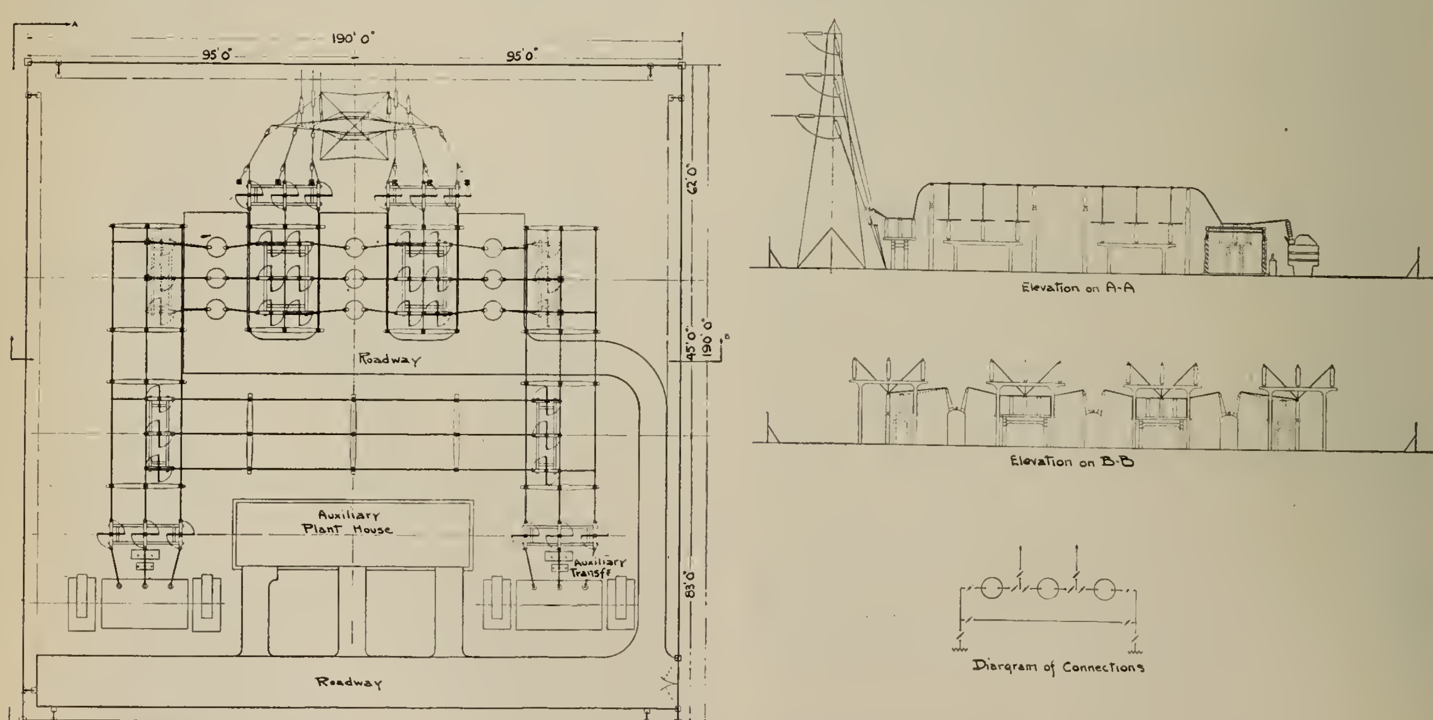


**Fig. 5—Typical Mesh-Type Substation.**

TABLE V
POSITION AT 31ST DECEMBER, 1936

| Scheme | Location of control centre | Area | Population 1935 | Electricity generated by public stations 1936* | Number of selected stations | Lengths of lines and cables under control | | | Number of switching and transforming stations | | | Length of communication channels |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 132 kv. | Lower voltage | Total | 132 kv. | Lower voltage | Total | |
| | | Square miles | | Millions of units | | Route miles | Route miles | Route miles | | | | Radial miles |
| Central Scotland, South Scotland | Glasgow | 9,268 | 4,142,544 | 1516.5 | 16 | 471 | 157 | 628 | 22 | 18 | 40 | 527 |
| North East England | Newcastle | 5,049 | 2,694,391 | 1253.0 | 6 | 91 | 89 | 180 | 5 | 11 | 16 | 203 |
| North West England and North Wales | Manchester | 9,082 | 7,146,567 | 3365.7 | 28 | 316 | 200 | 516 | 22 | 28 | 50 | 720 |
| Mid-East England | Leeds | 7,546 | 4,957,658 | 2321.3 | 17 | 323 | 202 | 525 | 12 | 16 | 28 | 479 |
| Central England | Birmingham | 7,311 | 5,736,373 | 3080.1 | 20 | 397 | 40 | 437 | 18 | 4 | 22 | 539 |
| South East England and East England | London | 12,266 | 13,812,849 | 6597.4 | 35 | 791 | 426 | 1,217 | 34 | 65 | 99 | 1,510 |
| South West England and South Wales | Bristol | 17,090 | 6,297,162 | 1667.7 | 15 | 609 | 113 | 722 | 20 | 14 | 34 | 996 |
| Totals | | 67,632 | 44,787,544 | 19801.7 | 137 | 2,898 | 1,227 | 4,125 | 133 | 156 | 289 | 4,974 |

*Provisional

Each control room is equipped with:—

(*a*) Combined telephone and automatic indicating equipment giving, over the single channel to each main grid point, direct telephone communication between the control centre and all main and important secondary grid points. Automatic indication is given of circuit breaker position and transformer ratio, of load transfers between grip sections and systems, and of important station outputs. Indication on demand is also given of less important station and transformer loads, and of system voltage at various points. Seven-point telegraphs are provided for routine signals to stations.

(*b*) A specially designed control desk or desks.

(*c*) A complete system diagram showing all lines, oil switches, isolating and earthing switches, and transformers, under the control of the Board.

(*d*) Frequency and time-control equipment.

Most of the equipments have been designed on automatic telephone principles. Remote metering indications are mostly provided on demand by impulse systems, and where continuous, by a photo-electric system.

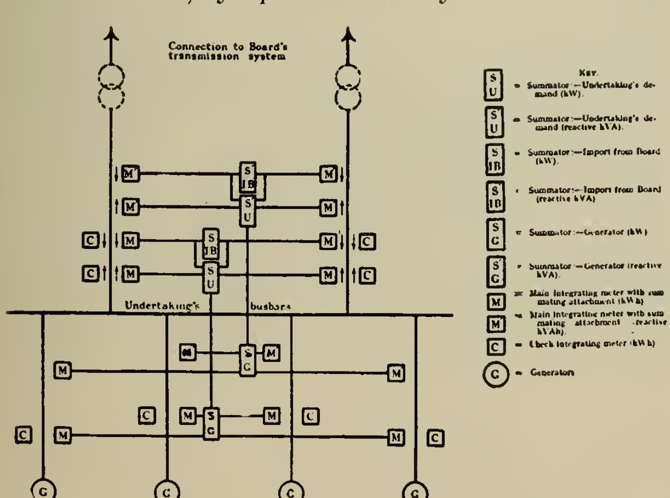


**Fig. 7—Metering Scheme for Stations with Generating Plant.**

The use of automatic telephone apparatus makes possible a convenient concentration of receiving devices. In the arrangement shown in Fig. 10, the circuit breaker ratio change and meter indicators are carried in a well in the front of a special desk.

**Fig. 8—Thames Crossing at Dagenham. Towers 497 ft. high, Span 3.060 ft.**

STANDARDIZATION OF FREQUENCY

The areas which had to be changed to the standard 50-cycle basis before the Grid system could be brought into full operation are shown in the map (Fig. 11). The magnitude of the work involved can be judged from the fact that it has entailed the rewinding or replacement of over 900 mw. of generating plant and 300 mw. of converting plant in addition to a huge amount of apparatus on consumers' premises.

It is worthy of note that motors having a total capacity of over 1,800,000 h.p. have been changed over to standard frequency without dislocation of industrial production.

But for the fact that growth of industrial equipment has been retarded by the trade depression from 1930 to 1934, the amount of apparatus to be dealt with would have been even larger. The work, which began towards the end of the year 1927, has been estimated to cost some £19 millions. While the actual cost will probably be less than that figure, it is safe to say that if the change had been delayed until the present time, the cost would have been in the neighbourhood of £30 millions.

THE GRID IN OPERATION

The introduction of a high voltage system of the magnitude of the Grid, in a highly developed and densely populated country such as Great Britain, involved administrative problems at least as great as those on the technical side.

The act gave the Board power to acquire wayleaves for its lines compulsorily, on reference to the Minister of Transport, but in spite of the magnitude of the task, involving negotiations with some twenty-two thousand separate landowners and tenants, and in spite of the fact that the establishment of a comprehensive national network of overhead lines was viewed with a natural concern by all those interested in the preservation of amenities, no serious delay was occasioned by wayleave negotiations, and resort to compulsion was only necessary in some 2½ per cent of the cases dealt with.

**Fig. 9—Metal Clad 132-kv. Switchgear at Tongland.**

Figure 12 gives a comprehensive summary of the progress from the time of the passing of the 1926 Act to full operation of all the schemes except North East England, where general trading is still deferred pending the completion of frequency standardization.

On the establishment of the Grid, the Board's operations fall naturally into two divisions:—

(i) those associated with the production and transmission of energy, and

(ii) those relating to the sale of electricity.

(i) *Production and Transmission.*

The 137 selected stations and 37 other stations under the directions of the Board vary widely in size and economy of production. Proximity to a coal field or to cheap sea transport facilities gives certain stations the advantage of a low coal price. A high thermal efficiency is obtainable with stations situated on the sea coast or on rivers with ample condensing water. Large and economical stations had been built to meet heavy electrical loads in the main population centres, but at other load centres the existing stations were less efficient.

By using only the best stations continuously and relegating the others to restricted operation, it is possible to produce the energy requirements of the system as a whole at a reduced over-all running cost.

The operating programmes aim at reducing the running costs of generation in each area to the minimum compatible with reliability of supply, on which considerable stress is laid in Great Britain.

Each of the seven systems into which the grid is divided is normally operated independently, and no attempt is made to transfer large blocks of energy from one area to another except in the case of the hydro-electric stations in South Scotland, which export most of their output to Central Scotland and North West England.

As a result of the concentration of production at the most economical stations, out of the 155 stations operating under the Board's directions in 1936 in the areas in which general trading was in force, only 26 ran the full 8,784 hours in the year, 27 others ran between 8,783 and 6,600 hours, 50 others between 6,600 and 2,400 hours, 47 less than 2,400 hours, while five were not in operation at any time during the year. Sixteen of the most economical of these stations produced over 50 per cent of the energy generated for the Board in those areas.

Figure 13 shows the growth of winter load between 1925 and 1935, and the magnitude of the normal daily variations for Great Britain except North Scotland.

Since the advent of the Grid the responsibility of arranging for generating plant extensions has devolved on the Board. The programmes of plant extensions are based on surveys of probable load development for the four ensuing years and after approval has been obtained from the Electricity Commission the Board issue formal directions to the station owners to carry out the extensions. In planning extensions of generating plant and of the Grid equipment each of the seven systems is considered separately. The interconnecting lines between these systems provide, however, an additional safeguard facilitating mutual assistance should occasion arise.

For the five years 1935-1939 inclusive, the Board have arranged for new plant at average annual rates of about 550 mw. for generators and about 6,700,000 lb. per hour for boilers together with the necessary reinforcing of the Grid system. The most usual sizes of machine are 30 mw. at 3,000 r.p.m. and 50 mw. at 1,500 r.p.m. with boiler pressures ranging from 400 to 600 lb. per sq. in. and superheat up to 850 deg. F. 40 mw. sets at 3,000 r.p.m. are, however, under construction, and 60, 75 and 100 mw. sets at 1,500 r.p.m. are in operation. In addition, a 50 mw. installation designed for operation at 1,900 lb. per sq. in. and 930 deg. F. is approaching completion.

**Fig. 10—Southwest England and South Wales Control Room, Bristol.**

(ii) *Sale of Electricity.*

Reference has already been made to the financial arrangements between the Board and selected stations, including the repurchase by the latter of the energy required for their own purposes.

As soon as general trading has begun in a Scheme Area, the Board is under obligation to furnish supplies to all distributing authorities in that Area who may demand supplies from the Grid, but the Board may decide whether a supply shall be given directly or indirectly through the system of some neighbouring authority. The interests of the indirectly supplied authorities are, however, safeguarded by a provision in the 1926 Act that they are to receive supplies on the same terms as the authority through which their supply is drawn, with the addition only of the actual costs and charges involved in transmission.


**Fig. 11—Areas Changed from Non-Standard a.c. Frequency.**

The first point of interest in the Board's tariffs is the fact that budgeting on a ten-year basis involves estimating the probable growth in the demand for electricity for that period, and assessing the costs of generation and transmission likely to be entailed in catering for the projected demand. Forecasting over such an extended period may at first sight seem rather hazardous, but it is after all no more so than that involved in the construction of any capital works of magnitude having an extensive period of life. Much of the expenditure, particularly that on plant extensions, can be regulated within the period if there are changes from the assumed rate of growth. Up to the present the growth assumed in the initial tariff calculations has been somewhat exceeded. The most inflexible element in the calculations is the cost associated with the initial Grid construction, which of necessity was planned to meet the future conditions envisaged at the time of the 1926 Act. The Weir Committee based their recommendations upon the assumption that public sales of electricity in Great Britain would amount to 21,385 million units by about the year 1940. Unlike other countries, the production of electricity in Great Britain did not register an actual decline even at the worst of the depression (the lowest annual increase being 4½ per cent in the year 1931). The total output of public stations in 1936 was 20,220 million units, corresponding to sales of about 17,000 millions; sales are now increasing by over 1,500 millions per annum, and there is thus little doubt that the general scale of electrical development will be such as to justify the estimates on which the Weir Committee's recommendations were founded.

The next point of interest is that although the principle of a small ultimate margin made it necessary to approximate as closely as possible to a true cost basis, so as to secure low initial prices, it was found possible to introduce promotional elements into the tariffs, to encourage load development.

In the first place, the fixed charge per kilowatt is related to the "basic" demand of the authority taking the supply, defined as the demand upon that authority by its consumers in 1932, subject to a minimum of 2,000 kw. Any demand in excess of that "basic" level is supplied at three lower grades of kilowatt charge, the steps being related to "standard increments" of demand which vary inversely with the amount of the basic demand.

Secondly, the period during which the chargeable maximum demand is measured is restricted to the four months of January, February, November and December in each year, and it is thus possible for a distributing authority supplied at the tariff to develop new loads during the eight summer months without incurring additional kilowatt charges, thereby encouraging improvement of load factors.

Apart from these two features, the tariffs follow normal practice by incorporating a fuel clause, designed to cover changes in wage levels and general prices as well as alterations in the calorific value and price of fuel, a power factor clause penalizing authorities whose power factor of supply is below 0.85 lagging, and a rates clause reflecting variations in the level of local taxation. All demands are measured on a half-hourly basis.

The principal features of the Grid tariffs so far in force are summarized in Table VI.

It was realized that certain non-selected stations could with advantage be utilized during the remainder of their economic life. Arrangements were accordingly made for them to be operated for the time being under the directions of the Board for peak load and standby purposes, the

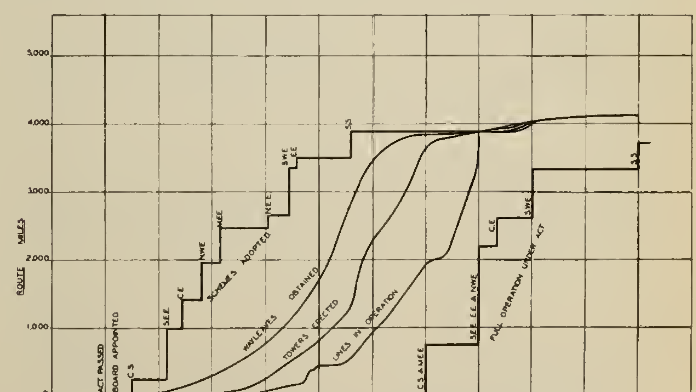


**Fig. 12—Progress of Grid Schemes.**

Board supplying the whole requirements of the owners and paying appropriate rentals for the use of the stations. As the outstanding capital expenditure on the stations is amortized, the rentals can be gradually reduced until ultimately the stations are closed down, the owners continuing to purchase the whole of their requirements from the Grid. Such arrangements have mainly been made with distributing authorities in respect of their own generating stations, but in a few cases somewhat similar arrangements have been made in regard to generating plants owned by large industrial consumers, which are operated on behalf of the Board through the local distributing authority.

Sanction for such arrangements was conveyed by a further act in 1935, which also improved the flexibility of the Board's trading in two important respects. First, it empowered the Board (subject to the approval of the Electricity Commissioners) to give a special supply to a distributing authority, at a rate different from the Grid tariff, for the purposes of an industrial consumer whose circumstances were so special as to justify an exceptionally low rate. Secondly, it permits the Board (again after approval by the Electricity Commissioners) to give direct traction supplies to railway companies, subject to a limited veto by selected-station owners on the use of such supplies within the areas controlled by them.

### Effects and Results of the Grid

While the Grid will not be seen in its true perspective at least until the first ten-year period of normal operation has elapsed, some of the more salient results have already become visible.

In the first place, the policy which was planned in the comparative prosperity of 1924-1929 was largely executed in the following years of depression and contributed in no small measure to the alleviation of conditions during that period. For the Grid as originally designed and constructed, 150,000 tons of steel were required for more than 26,000 lattice-work towers and for the steel cores for conductors on 4,000 route miles of transmission line. 12,000 tons of aluminium were also required for the overhead lines and some 200,000 strings of insulators and porcelain bushes. Coal mining, iron and steel manufacture, cable making, electrical engineering, cement, pottery, building and contracting industries all made their contribution to the Grid scheme. The cost, approximately £27,000,000, was within 2½ per cent of the original estimates.

Not only did the construction of the Grid have a beneficial effect upon national employment, at a time of acute depression, but the experience in high voltage construction which it entailed has placed British manufacturers once more in the forefront of technical progress.

The first effect to be looked for from the establishment of the Grid is the reduction in the plant capacity needed to satisfy a given demand. During the years immediately prior to the establishment of the Grid, the amount of spare plant which it was necessary to maintain as an insurance against breakdown was steadily rising, due mainly to the large sets then coming into use, which entailed the retention of commensurate standby capacity. While the Grid was

Table VI
Comparison of Grid Tariffs

| Area | Fixed Charge per Annum | | | | | | | Running Charge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Charge per Kilowatt (*a*) | | | | Variations | | | | Variations | | |
| | | | | | | For rates of local taxation | | | | | |
| | of basic demand (*b*) | of first standard increment of demand (*b*) | of second standard increment (*b*) | of all excess | For power factor (*c*) | Basic rates (*d*) | Variation per 1/– departure from basic rates | Charge per kw. h. | Basic cost of fuel per ton | Basic calorific value of fuel (B.t.u. per lb.) | Variation per –/1d. departure from basic cost at basic C.V. |
| | £ s. d. | £ s. d. | £ s. d. | £ s. d. | s. d. | s. d. | s. d. | Pence | s. d. | | Pence |
| Central Scotland.. .. | 3 10 0 | 3 5 0 | 3 0 0 | 2 15 0 | 4 6 | 6 0 | 1 10 | 0.200 | 13 6 | 11,000 | 0.001 |
| South Scotland...... | 3 10 0 | 3 5 0 | 3 0 0 | 2 15 0 | 4 6 | 3 0 | 1 10 | 0.200 | 13 6 | 11,000 | 0.001 |
| N.W. England and N. Wales.......... | 3 7 6 | 3 3 0 | 2 18 6 | 2 14 0 | 4 6 | 4 0 | 1 10 | 0.200 | 15 0 | 11,600 | 0.0009 |
| Mid East England.... | 3 10 0 | 3 5 0 | 3 0 0 | 2 15 0 | 4 6 | 5 3 | 1 10 | 0.186 | 13 0 | 11,500 | 0.001 |
| Central England..... | 3 10 0 | 3 5 0 | 3 0 0 | 2 15 0 | 4 6 | 4 0 | 1 10 | 0.196 | 12 0 | 10,000 | 0.001 |
| S.E. and E. England.. | 3 10 0 | 3 5 0 | 3 0 0 | 2 15 0 | 4 6 | 4 3 | 1 10 | 0.210 | 16 0 | 11,500 | 0.0008 |
| S.W. England and S. Wales.......... | 3 10 0 | 3 5 0 | 3 0 0 | 2 15 0 | 4 6 | 4 6 | 2 0 | 0.225 | 14 6 | 12,700 | 0.0008 |

(*a*) of maximum demand upon the Board in January, February, November and December, i.e., twice the highest half-hourly number of kw.h. supplied and taken in those months.

(*b*) "Basic demand" means the M.D. on the distributing authority's system in 1932, or 2,000 kilowatts, whichever is the greater. "Standard increment of demand" means an increase over the basic demand in accordance with the following scale:—

| Basic Demand | Standard increment | Basic demand | Standard increment |
|---|---|---|---|
| Not exceeding 3,000 kw.... | 3,000 kw. | Exceeding 13,000 but not exceeding 14,000 kw.... | 1,900 kw. |
| Exceeding 3,000 but not exceeding 4,000 kw.... | 2,900 kw. | Exceeding 14,000 but not exceeding 15,000 kw.... | 1,800 kw. |
| Exceeding 4,000 but not exceeding 5,000 kw.... | 2,800 kw. | Exceeding 15,000 but not exceeding 16,000 kw.... | 1,700 kw. |
| Exceeding 5,000 but not exceeding 6,000 kw.... | 2,700 kw. | Exceeding 16,000 but not exceeding 17,000 kw.... | 1,600 kw. |
| Exceeding 6,000 but not exceeding 7,000 kw.... | 2,600 kw. | Exceeding 17,000 but not exceeding 18,000 kw.... | 1,500 kw. |
| Exceeding 7,000 but not exceeding 8,000 kw.... | 2,500 kw. | Exceeding 18,000 but not exceeding 19,000 kw.... | 1,400 kw. |
| Exceeding 8,000 but not exceeding 9,000 kw.... | 2,400 kw. | Exceeding 19,000 but not exceeding 20,000 kw.... | 1,300 kw. |
| Exceeding 9,000 but not exceeding 10,000 kw.... | 2,300 kw. | Exceeding 20,000 but not exceeding 21,000 kw.... | 1,200 kw. |
| Exceeding 10,000 but not exceeding 11,000 kw.... | 2,200 kw. | Exceeding 21,000 but not exceeding 22,000 kw.... | 1,100 kw. |
| Exceeding 11,000 but not exceeding 12,000 kw.... | 2,100 kw. | Exceeding 22,000.............................. | 1,000 kw. |
| Exceeding 12,000 but not exceeding 13,000 kw.... | 2,000 kw. | | |

(*c*) Increase of kw. charge per 0.1 in P.F. below 0.85 lagging.

(*d*) Average local taxation for the year in respect of all the selected stations in the area, per kilowatt of the generating plant in those stations at the beginning of the year.

under construction, the proportion of standby plant remained approximately constant in spite of further increases in demand, as sections of the Grid were coming into operation, and thus uneconomical plant extensions were being avoided. It will be seen from Fig. 14 that since 1933, when general trading began, reserve plant has been absorbed very rapidly until today, with the Grid not yet in full operation, it represents not much more than the minimum which will be required under conditions of completely

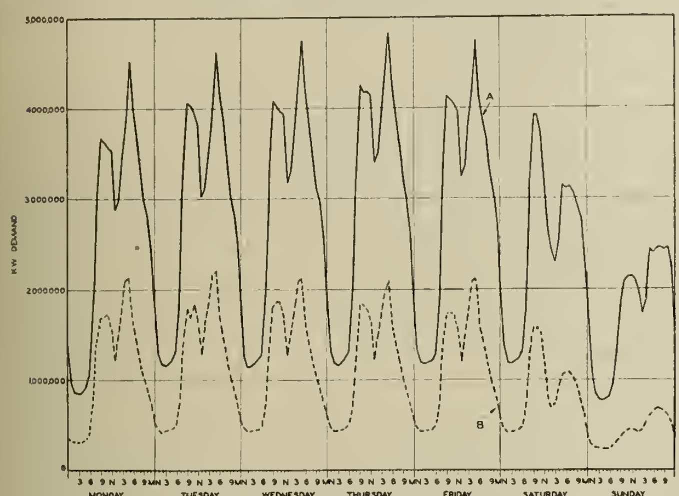


**Fig. 13—Aggregated Load Curves Winter Week.**
**Curve A—December 16-22, 1935.**
**Curve B—December 14-20, 1925.**

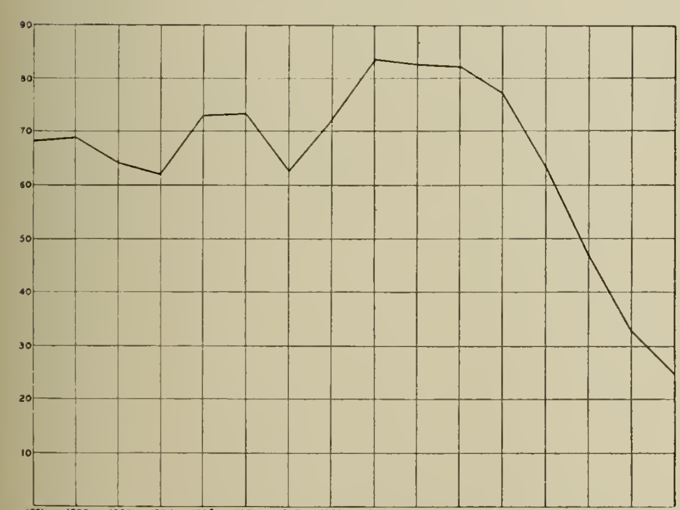


**Fig. 14—Reserve Plant in British Public Stations as Percentage of Aggregate Demands thereon.**

interconnected working. Future plant extensions will, therefore, be proportionate to the actual growth in demand upon the system, which can, however, be met by the installation of a relatively smaller amount of additional plant. The net savings in reserve plant, which at the end of 1936 were already estimated to amount to some £14,000,000 will, therefore, continue to grow.

Apart from the reduction in reserve plant brought about by the Grid, the concentration of production into the most efficient stations has resulted in a very considerable increase in the aggregate thermal efficiency of the system and a corresponding decrease in fuel consumption. The extent of these economies can be judged from Fig. 15, in which the performance of the stations now associated with the system is compared with the performance of such of those stations as were in full operation independently in 1932. It will be seen from this diagram that thermal efficiency has increased by no less than 14 per cent of the 1932 figure, while the average fuel consumption per unit sent out from the stations has decreased proportionately. Part of this increase in efficiency, of course, arises from the better performance of the new plant installed in the selected stations since 1932, but this better performance is in itself partly attributable to the Grid, since larger individual sets are possible with interconnected working. In 1936 the average size of generator arranged by the Board to be installed was some 35 mw. which, as will be seen from Table II, is over four times the average capacity of a complete station in 1924-25. The magnitude of the saving on fuel can be judged by the fact that the overall fuel consumption of the system in 1936 was nearly two million tons less than it would have been at the 1932 average fuel consumption per unit. At the coal price ruling in 1935 this would have meant a saving in the fuel bill for the year of over £1,400,000, but as is well known, coal prices in Great Britain hardened in 1936 and at the average price actually paid in 1936, the saving amounted to nearly £1,600,000.

The full benefit cannot be felt by the consumers until the national demand for electricity has increased sufficiently to spread the charges incidental to the Grid over the market for which it was designed to cater. None the less, it is already clear that the Grid is having a marked effect upon the average costs of energy to the distributing authorities in general and this after all is the real criterion of whether the policy is sound. In recent years there was a marked

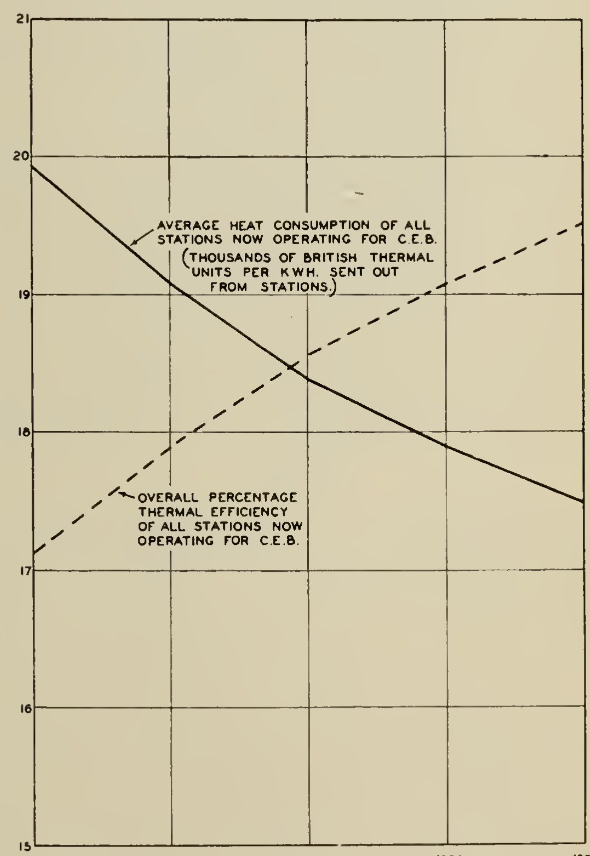


**Fig. 15—Fuel Reduction with Grid Operation.**

downward trend in average production costs even before the establishment of the Grid, due partly to the efforts of the supply authorities, but mostly to the general decline in national price levels after the War. To obtain some real measure of the contribution of the Grid to the economy of the supply industry, it is necessary first of all to eliminate this latter factor. In Fig. 16 are shown the total costs from 1921-22 to 1935-36 to the supply authorities of the country of the electricity required to serve their consumers, the costs having been adjusted for all price changes outside the control of the industry and also for the increase in load factor which has been a feature of electrical development in Great Britain in the last fifteen years. (Corrected to Load-Factor 33.24 per cent and price levels in 1934-35.) Since the costs in the later years include the amounts which have been paid by distributing authorities in respect of Grid supplies, the marked change in the curve since 1932 is effective evidence of the value of the Grid system.

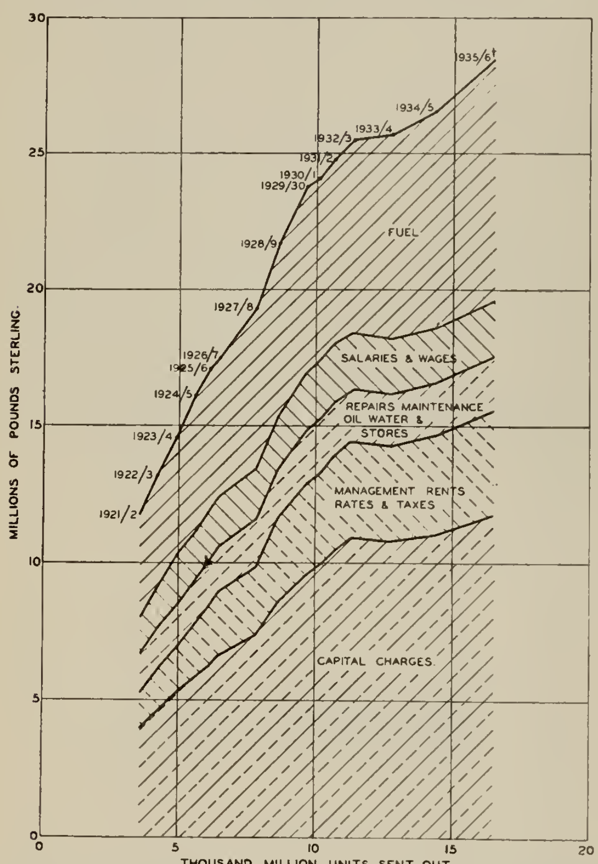


**Fig. 16—Total Costs of Energy sent out on local Distribution Systems.**
†Provisional.

The direct financial effects of the Grid policy are not the only measure of its value to the community. It can be claimed with confidence—and the figures in Table I adequately support the claim—that the existence of the Grid has brought about the development of supplies in rural areas far more rapidly than would have otherwise been the case, with a consequent increase of the amenities of country life. It has undoubtedly assisted in the decentralization of industry and has thus made possible more rational planning of national life. Railway electrification has also received an impetus and one of the principal railway systems of the country—the Southern Railway, which serves the majority of South East England—is now in an advanced stage of main line electrification. Incidentally, the Grid has caught the popular imagination and has undoubtedly advertised electricity in the public mind with a consequential increase in the pace of domestic electrification.

Although inaugurated by an act of Parliament, such a system could not have been superimposed on the electricity supply industry without the co-operation of all parties. From the outset, the Board has endeavoured to be not a separate entity, but an integral part of the public electricity supply industry. To that end, technical consultative committees, representative of the principal supply interests, have been set up in each scheme area, with whom the Board consult on such questions as local trading arrangements, operating programmes and plant extensions, while questions of general principle are discussed with a National Consultative Committee, representative of the whole supply industry. The existence of these committees and the establishment of central control rooms for each area permit of extremely rapid dissemination of important information, while the adoption of a unified system of costing in the production side of the industry has resulted in data being quickly available on a comparable basis for all the stations associated with the Grid.

### Problems Still Awaiting Solution

It will have been seen from the foregoing that the Grid system is now well established and is in a fair way to performing the functions for which it was set up. The problems on the production and main transmission side may reasonably claim to be nearing solution. It is not desired to imply, however, that the whole of the problems of the electricity supply industry in Great Britain have been resolved thereby. Much still remains to be done before the legacy of over fifty years of piecemeal development are overcome. The 1926 Act provided for the standardization of the alternating current frequencies employed, but did not deal with the multiplicity of voltages in use in the low tension distribution networks. Furthermore, considerable portions of these networks are still operated on direct current, while the multitude of separate authorities has naturally led to an enormous variety of tariffs, some of which are promotional in character and encourage development, while others unfortunately have a retarding effect. The whole field of the distribution side of the industry has recently been the subject of a Governmental enquiry, presided over by Sir Harry (now Lord) McGowan. The report of that committee was published last year and is now under consideration by the Government. With that report still *sub judice*, it is too early to make any definite statement on distribution matters, but no doubt the problems will be energetically tackled and the industry will be able to face with confidence a future in which electricity is destined to be of supreme national importance.

To sum up, the rapidity of the growth of the supply industry in Great Britain since the Grid was established, and during a period of world-wide depression, shows that the Grid, which is the first step in the national reorganization of electricity supply, has been established without dislocation to industry and is being of material assistance to it. The policy is undoubtedly sound—indeed it is difficult to see any practicable alternative—and there is every prospect that it will be a financial success. It has made exceptional demands upon the British manufacturers of high voltage electrical apparatus, who have met all the demands made upon them in the best British tradition of design and craftsmanship. The energy hitherto expended in overcoming the retarding influence of small scale individual production is now released for the more important function of load building. There is, therefore, good ground for believing that with the handicaps of the past overcome, electrification in the Mother Country, which is now proceeding apace both industrially and on the domestic side, will soon approach the high level which has been achieved in these fields in the great Dominion of Canada.

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# The Borden Bridge, Saskatchewan

## A Reinforced Concrete Bow-String Highway Bridge over the North Saskatchewan River at the Ceepee Crossing of the Jasper Highway.

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**Paper to be presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—This paper covers the design and construction of a reinforced concrete highway bridge with three tied-arch spans, the longest being 213 ft. The substructure work was done under very severe winter conditions. Maximum concrete stresses in the arch rings were reduced by using temporary reinforced concrete hinges at the crowns. Records of concrete temperature are given, also figures as to quantities and costs.

The Borden bridge, a reinforced concrete structure approximately 851 ft. long, was built in 1935-36 to replace the "Ceepee" ferry where the Jasper highway crosses the North Saskatchewan river about forty miles northwest of Saskatoon. The existing location and elevation of the highway at this crossing demanded that the bridge floor line should be no higher than necessary to clear flood waters, and a through type of bridge was clearly indicated. A reinforced concrete structure was favoured by the local authorities, not only on account of appearance and economies in maintenance, but also due to the larger percentage of local labour that would be thereby provided. The nature of the river bottom on the west bank made the consideration of fixed elastic arch spans unattractive, and, as the bridge had to be of the through type in any case, bow-string or tied arches were adopted for the major spans, as such structures are unaffected by slight pier settlements or rotations, and would not require an expensive thrust pier on the west bank. A study of different span lengths and arrangements indicated that the most economical and pleasing combination consisted of three bow-string arches flanked by girder spans as shown in Figs. 1 and 2.

Compared to European practice, there are few very long span concrete bridges on this continent, although arches up to 460 ft. have been built in the United States.[1] In Europe there are several arch bridges approximating 600 ft. in span.[2] These are deck structures built in cellular construction and with the aid of hinges, either temporary or permanent, two valuable design features that might with advantage be made more use of on this continent. A through arch bridge, claimed in 1935 to be the largest of its kind, was built at La Roche-Guyon, France, with a clear span of 528 ft.[3]

Bow-string spans, however, have never approached the above dimensions and, as far as the authors have been able to learn, the largest span of this type in America was built during 1935-36 by McCullough in Oregon[4] with a span of 210 ft. centre to centre of piers. Elsewhere such bridges have been built at least up to spans of about 300 ft. as in Tunisia.[5] In Canada many small highway bridges of this type have been built, but few, if any, with a span greater than 150 ft. The Borden bridge has a centre span of 213 ft. and thus in Canadian practice can be considered a long span of this type. It is proposed, therefore, to discuss in detail certain aspects of design and construction that become controlling factors in such cases but are not so important in shorter spans, and which, it is hoped, will be of value to engineers interested in highway bridge construction.

This paper is divided into three sections. Part I deals with design features, Part II with experimental data obtained during construction, together with calculations and conclusions arising out of these observations, while in Part III construction experiences and aspects are described and a brief statement of quantities and costs presented.

### I. DESIGN

From the aesthetic standpoint an attempt was made to obtain a pleasing effect by careful proportioning only, as it was considered that, on such a rural highway bridge, panelling or other decorative features would be inappropriate. The roadway line from abutment to abutment was constructed on a flat parabolic curve obtained by making the middle piers five inches higher than the other two. The centre span was made slightly longer than the adjacent ones and the crowns of the arches are therefore points on a parabola of sharper curvature but in keeping with the deck line; a camber of three inches was provided in the floor system of individual spans and the resultant elevation of these members together with the arch outline, which is also parabolic, is pleasing. The handrailing on the girder spans, made of a substantial concrete section, gives a sense of security on these short deck spans, and harmonizes

[1]George Westinghouse bridge, 460 ft.; Engineering News-Record, April 23, 1931.
[2]At Esla, Spain, 645 ft.; Civil Engineering (English), October, 1935. At Brest, France, 612 ft.; Engineering News-Record, October 31, 1929. At Stockholm, Sweden, 593 ft.; Engineering News-Record, June 7, 1934.
[3]Engineering News-Record, September 5, 1935.
[4]Engineering News-Record, November 14, 1935.
[5]Le Génie Civil, September 17, 1927.

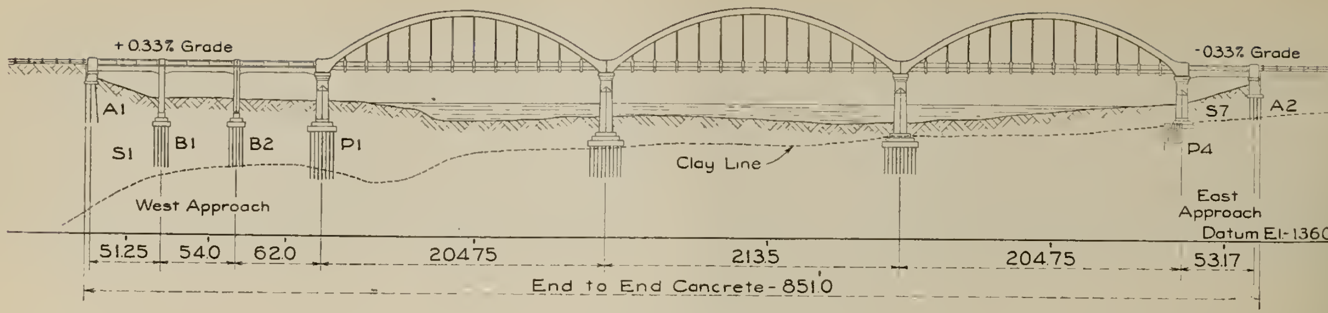



Fig. 1—Elevation of Bridge.

well with the heavy arch ribs and terminal blocks over the end piers. On the arch spans a steel fence, painted a dark green, not only lightens the dead weight, but with the slender verticals and shallow fascia beams emphasizes the functional aspects of the main members. The overhead sway bracing, potentially unattractive, was designed and constructed so that each member lies on a warped surface, the upper and lower surfaces forming part of an imaginary plane following the curvature of the arch rings, and, while the form work was thus complicated somewhat, the result was well worth the effort; Fig. 3 is a photograph illustrating the effects obtained.

### Specifications—Loading and Stresses

In general the specifications of the Canadian Engineering Standards Association for Highway Bridges and Reinforced Concrete were followed and the following loads and stresses assumed:

Live Loads:—Slab, floor beams, girders, hangers; two 15-ton trucks abreast plus 30 per cent impact.
Foundations, arch rings, horizontal ties; uniform load 80 lb. per sq. ft.
Wind:—30 lb. per sq. ft. on vertical projection of spans.
Temperature:—General range, 130 deg. F.
Differential lag between arch rib and horizontal tie temperature 20 deg. F.
Concrete Class "A"—arch rings, sway bracing . . 3,500 lb. per sq. in.
Concrete Class "B"—substructure above elevation 1445, superstructure except in "A" . . . . . . . . . 3,000 lb. per sq. in.
Concrete Class "C"—substructure below elevation 1445 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2,500 lb. per sq. in.
Concrete flexure stresses were limited to 1,000 lb. per sq. in. in arch rings and 1200 lb. per sq. in. in floor system and girders. Steel stresses in the horizontal tie and vertical hangers were limited to 18,000 lb. per sq. in., while 20,000 lb. per sq. in. was allowed in other members.

### Foundations

The general foundation conditions are shown in Fig. 1. Wash borings indicated that the river bed varied greatly over its width. On the east bank yellow clay outcropped at the surface and pier 4 was located on a hard glacial clay into which it was unnecessary and impractical to drive bearing piles. The clay stratum dipped continuously towards the west end where it was overlain with 60 ft. of fine river sand. The top of the clay stratum, which appeared from the wash borings to be firm boulder clay, as is usually found below the boulder line in this region, was found during construction to be far from firm or uniform and was interspersed with lenses and pockets of soft material, sand and boulders, which created many unforeseen difficulties; the dotted line on Fig. 1 shows the hard firm clay line as found, which was overlain by softer clay, three to ten feet thick.

All foundations were designed carefully to avoid excessive and differential settlements. Records of settlement taken by the authors on another bridge on the South Saskatchewan river[6] showed that a differential settlement between upstream and downstream ends of one-half inch had occurred on all river piers due to the unsymmetrical base plan caused by the ice breaker provisions on the upstream end of piers, an almost uniform practice on Saskatchewan river bridges. Consequently, a corresponding base extension, as shown in Fig. 4, was provided on the downstream end of piers, in order to make pier bases perfectly symmetrical, and settlement records to date indicate that no measurable differential settlement has taken place. Table I shows the foundation loading used and the settlements recorded.

[6]Broadway Bridge; Engineering Journal, January, 1934.

Fig. 2—General View of Bridge.

Fig. 3—Sway Bracing and Other Details.

On the Saskatchewan rivers erosion of the bed around piers is a serious matter, both during construction and at subsequent flood periods. After careful studies it was decided that the river piers should be carried down 17 feet below the stream bed as it existed when borings were taken. Subsequent experience during construction proved that this allowance was not too liberal, as during a temporary ice jam in October, 1936, quite extensive areas around pier 2 were eroded down to within a few feet of the pier base. As a further precaution, a rock fill mat was placed over this area and around all other piers and foundations, and it is felt that after all falsework piles and cofferdams are removed there will be little danger of further excessive erosion around the piers.

### Girder Spans

Figure 1 shows the general arrangement and Fig. 5 the design details of the girders, columns and abutments. Expansions for spans 1, 2, and 3 were taken care of by hinged rockers at the western abutment and split hinged columns at bent 2. All of these hinges are of the Mesnager type designed according to the recommendation of Moreel, Parsons and Stang.[7] This semi-articulated method was chosen primarily because the sand bar on which the columns are located may be subjected to combined flood and severe ice conditions and a rugged, well-integrated structure was desired.

The expansion for span 7 was taken care of by steel rollers and bearing plates. This design was selected in order to obtain comparative costs and operating characteristics of reinforced concrete rockers and rollers. Cost data subsequently proved the former to be much cheaper than rollers, and the limited observations obtainable to date suggest the former are equally satisfactory in operation.

Records of actual expansions, during the past ten months, indicate that the movement of the hinged rocker end of the west girder span has been only about two-thirds of the theoretical. It is felt that there is an appreciable restraint in the rocker and that it would have been better had either the concrete covering at the hinges been reduced to one-quarter inch or horizontal mastic layers of one inch been used to separate the concrete at these sections.

The girder spans are of ordinary design and were proportioned to care for stresses due to a 1-in. differential settlement of supports as well as the specified loading. Rigid frame analyses of the fixed end girders and column bents suggested the advisability of placing hinges in the split columns in order to relieve bending stresses. Table II gives a summary of the calculated column stresses under hinged and fixed conditions.

[7]Journal, American Concrete Institute, January and March, 1935.

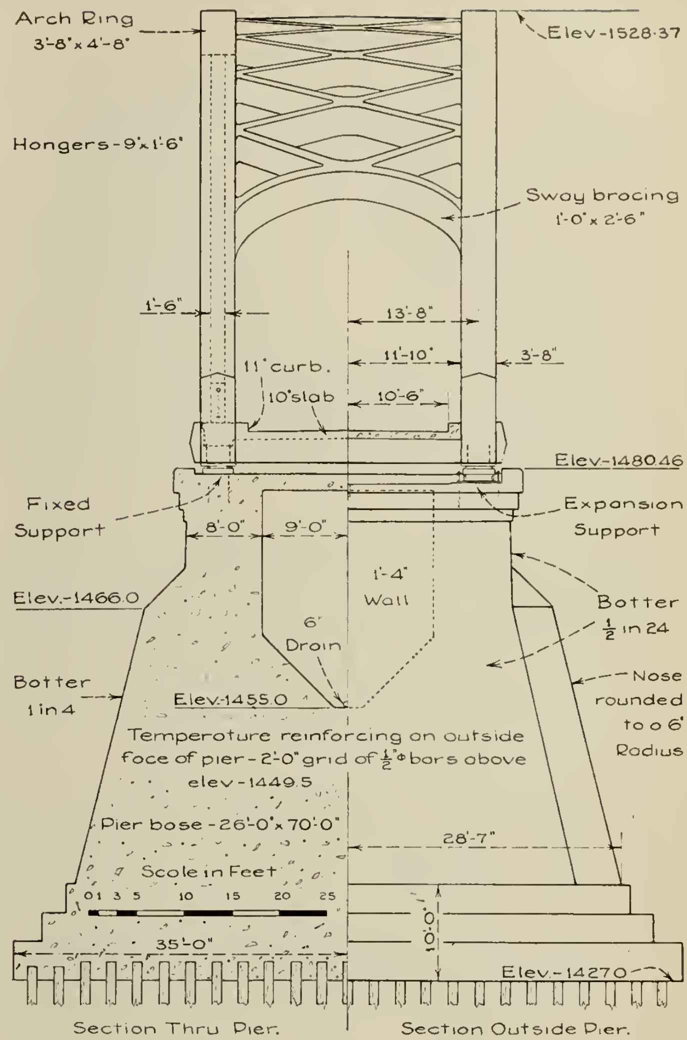



**Fig. 4—Side Elevation of Pier with Superstructure.**

### Table I

#### Foundation Loads and Settlements

| Foundation | Type | Dead load of bridge plus pier surcharge (1) | Sub-structure completed | Super-structure completed | Initial settlement reading | Total settlement at Nov. 23rd, 1936 (2) |
|---|---|---|---|---|---|---|
| Pier 1 | Pile foundation in sand. 171—35 ft. piles. | 18 tons per pile | July 28/36 | Oct. 30/36 | July 28/36 | 0.041 ft. |
| Pier 2 | Pile foundation in firm clay. Moisture content 24 per cent. 225—24 ft. piles. | 18 tons per pile | April 1/36 | Oct. 30/36 | Aug. 13/36 | 0.043 ft. |
| Pier 3 | Pile foundation on shale, plastic clay and quick sand. Clay moisture content 27 per cent. 225—14 to 30 ft. piles. | 18 tons per pile | Mar. 12/36 | Oct. 10/36 | June 23/36 | 0.048 ft. |
| Pier 4 | Foundation on hard clay interspersed with gravel. Moisture content 12 to 14 per cent. | 2.9 tons per sq. ft. | Nov. 22/35 | Sept. 19/36 | Nov. 22/35 | 0.041 ft. |
| Abut. 2 | Piles in clay containing sand pockets. 48—16 ft. piles. | 10 tons per pile | Dec. 4/35 | June 11/36 | Mar. 13/36 | 0.038 ft. |

(1) Surcharge was about 15 per cent of total

(2) Levels taken on March 3rd, 1937, showed that no further settlements had occurred.

Table II
Moments at Column Top—Bent 2
Length = 28.0 ft.

| | Column without hinge | Column hinged as shown |
|---|---|---|
| Dead load = | 200,000 ft.-lb. | 158,000 ft.-lb. |
| Live load = | 58,000 ft.-lb. | 46,000 ft.-lb. |
| Impact = | 17,400 ft.-lb. | 13,800 ft.-lb. |
| Temperature = | 91,000 ft.-lb. | 47,500 ft.-lb. |
| Total = | 366,400 ft.-lb. | 265,300 ft.-lb. |
| Max. $f_c$ = | 1,650 lb. per sq. in. | $f_c$ = 1,192 lb. per sq. in. |
| $f_s$ = | 31,500 lb. per sq. in. | $f_s$ = 19,450 lb. per sq. in. |

*Bow-String Spans*

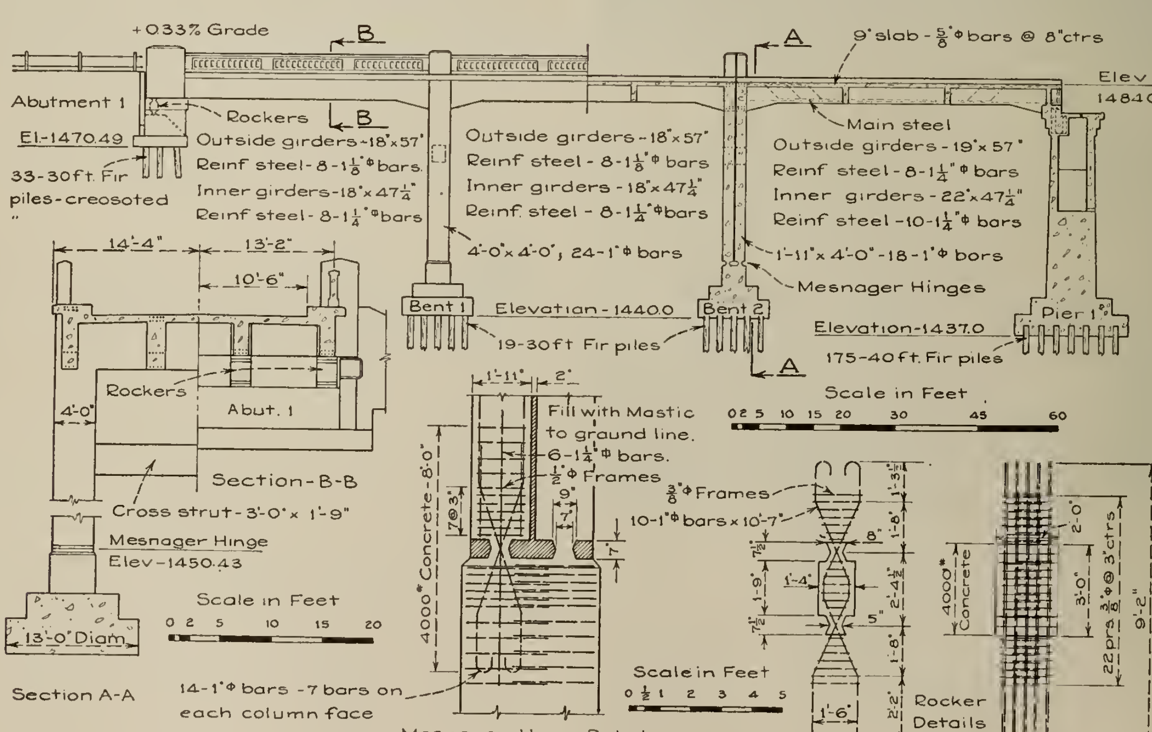
These spans constitute the most interesting elements of the bridge and the design will be discussed in some detail together with test data on the behaviour of the structure during and after construction. Figure 6 shows clearly the general dimensions, reinforcement and other design features of span 5.

Bow-string, like other arches, are subject to stresses caused by dead and live loads, arch shortening and concrete shrinkage, but the large temperature stresses found in fixed elastic arches, exposed to wide temperature variations, are theoretically absent. There are, however, other potentially large stresses brought about during construction, due to the elastic elongation of the horizontal tie when the falsework is struck, and the resultant horizontal movement of the supports which causes bending moments in the arch ring.

It has been general practice in this country to design bow-string spans as two-hinged arches, to construct the arch rib and horizontal tie together, and permit the moments, due to elastic elongation of the horizontal tie, arch shortening, concrete shrinkage, and temperature differentials to be taken by arch rib stresses. In longer spans such stresses become comparatively large and the resultant arch sections uneconomical. In the design under review, it was decided to provide temporary hinges at the crown and to obtain practical articulation at the springing by using a spherical bearing support and temporarily omitting the concrete in the end panels of the horizontal tie, in order that the structure might act substantially as a three-hinged arch during construction and thus relieve most of the potential arch ring stresses due to tie elongation, arch shortening, concrete shrinkage and arch temperature drop during construction. That well over eighty per cent of the potential moment was relieved by the hinges will be shown later when the results of experimental measurements taken in the field are discussed. Suffice it to say, for the present, that had temporary hinges not been employed it would have been impossible to keep the stresses down to the maximum used with a solid rectangular section of any size and the best possible section would have been considerably deeper in which maximum stresses would have been 125 lb. per. sq. in. greater than in the design adopted.

When designing it was assumed that the arch rib, horizontal tie and floor beams would be poured first and that after the falsework had been struck under these members, the floor system would be poured and when the arch was carrying this full dead load, the vertical hangers and end panels of the ties would then be concreted, and the temporary crown hinge filled in, making the arch continuous. It was assumed that thereafter the structure would act as a two-hinged arch, subject to live loads and small temperature stresses, due to the fact that the heavy arch section will have a temperature lag in relation to the smaller heavily reinforced tie; it was assumed that this lag would be 20 deg. F. on both rising and falling temperatures, but readings obtained during the past six months indicate that the differential will probably never be greater than 15 deg. F. Accordingly, the structure was designed as a two-hinged arch subject to dead and live loads, partial concrete shrinkage and a small temperature effect.

The arch rings, reinforced with 0.08 per cent of steel, are rectangular in section and of the same size throughout. The dimensions were determined by considerations of stress, stiffness and width required for the crown hinges. In calculating stresses a dead load eccentricity of 0.1 ft. was assumed in the direction to give maximum stress.




Half Elevation in sections of Girder Spans.

**Fig. 5—Details of Girder Spans.**

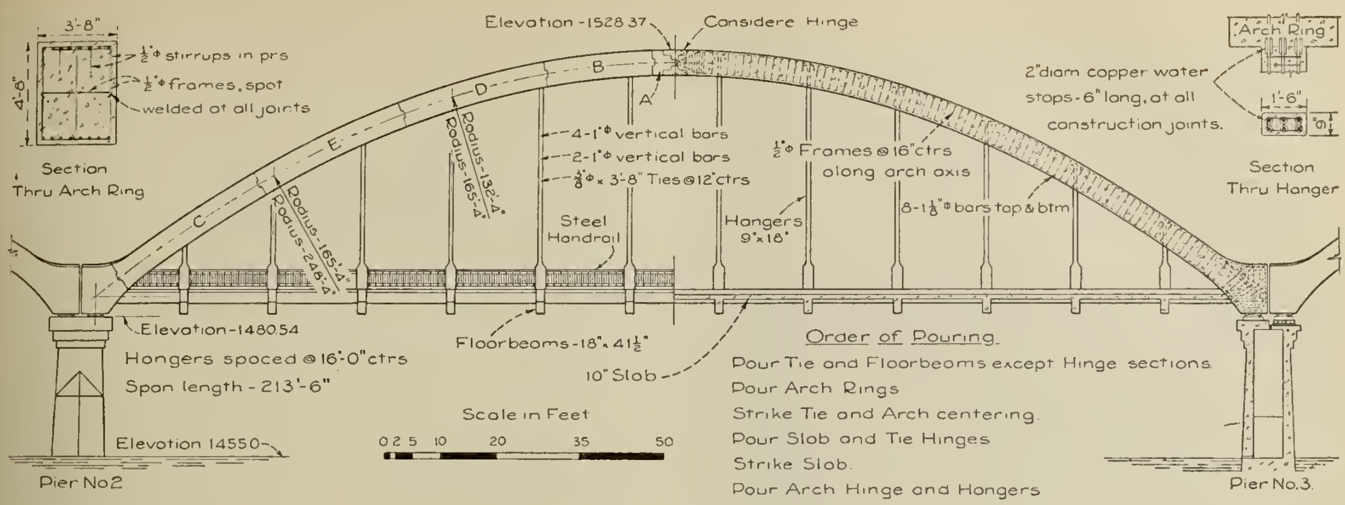



**Fig. 6—Elevation of Span 5.**

Table III shows calculated stresses at the quarter point of span 5 and indicates that the theoretical stress reductions obtained by using a crown hinge amount to over 200 lb. per. sq. in. or about 20 per cent.

TABLE III
CALCULATED STRESSES AT QUARTER POINT—SPAN 5

| | With Temporary Crown Hinge as Constructed | | | Without Temporary Crown Hinge | | |
|---|---|---|---|---|---|---|
| | Stresses—lb. per sq. in. | | | Stresses—lb. per sq. in. | | |
| | Direct | Bending | Total | Direct | Bending | Total |
| Dead load | −392 | 47 | −439 | −392 | 51 | −443 |
| Live load | − 19 | 318 | −337 | − 19 | 353 | −372 |
| Temp. variation 20 deg. F. | + 1 | 38 | − 37 | + 1 | 42 | − 41 |
| Conc. shrinkage | + 2 | 53 | − 51 | + 2 | 69 | − 67 |
| Arch shortening | 0 | 0 | 0 | + 1 | 27 | − 26 |
| Arch temp. drop during construction 20 deg. F. | 0 | 0 | 0 | + 1 | 42 | − 41 |
| Tie extension | 0 | 0 | 0 | + 4 | 114 | −110 |
| Totals | −408 | 456 | −864 | −402 | 698 | −1100 |

HORIZONTAL TIE

The horizontal tie is a tension member consisting of forty $1\frac{1}{4}$ in. sq. bars encased in concrete as shown in Fig. 7. The bars were spliced by lapping forty diameters and hooking the ends; welding was considered but the expense of obtaining reliable welding at this location and the difficulty of welding and placing so many and such long bars made simple lapping more attractive.

Bar lengths varied from 40 to 67 ft. and the splices were carefully staggered so that no more than two-fifths of the total number of bars were spliced in any one panel. As shown, the member was well tied transversely and laboratory tests indicated that with the ratio of concrete volume to spliced bars at any vertical transverse section and with the ample transverse ties the factor of safety for splices was high; the total longitudinal steel being 7.5 per cent and the transverse ties 0.3 per cent by volume of the core.

The horizontal tie was designed to carry a total direct tension of 1,078,000 lb., equivalent to a unit stress of 17,300 lb. per. sq. in. with bending stresses due to dead load between hangers of about 700 lb. per. sq. in. Wind stresses will be only a few hundred lb. per. sq. in.

The manner in which the horizontal tie elongated, due to direct tension, was interesting. Careful measurements, to the nearest 1/100 of an inch, were made of the movement of the free ends of ties and it was found that in all cases the concrete of the tie section took a very large proportion of the total tension when first stressed, but within a few months most of this was transferred to the steel. To illustrate, on span 5 the first day after the arch rings and ties were decentred the elastic elongation of the tie was only 0.55 in. compared with a theoretical extension of 0.96 in. on the assumption that all tension was carried by the steel alone: this means that the concrete was carrying then over 42 per cent of the total tension and was stressed to about 285 lb. per. sq. in. At the end of thirty-five days, when the floor system had been poured, the total elastic elongation was 1.08 in. with a theoretical indicated value of 1.27 in. for action of steel only. After five months there was little further elastic elongation, which shows that the initial tension of the concrete was transferred gradually to the steel, and apparently after the floor slab was poured some of the tension was carried by this member. It is possible that the delayed extension of the tie was due to the plastic flow of the concrete but it was also observed that very fine transverse hair cracks appeared in the tie concrete section at intervals of about 18 inches.

That a percentage of the extension of the horizontal tie was deferred until after the crown hinge was closed means that the arch stresses were increased perhaps 40 lb. per. sq. in. at the quarter point over the design assumptions.

The connection between the arch rib and horizontal tie was designed to transfer the forces with as little moment as possible and approximate calculations for shear and moment conditions indicate that the joint as designed was of ample strength. Figures 7 and 8 show plan and photograph of this detail, and while the density of reinforcement is apparent, concrete was placed readily and satisfactorily with the aid of a vibrator.

HANGER STEEL

Probably the most unsatisfactory results were obtained with the vertical hangers due to the fact that they were anchored in the tie when the arch rib concrete was being placed, and, as the arch falsework deflected with respect to the tie, deflections of the steel occurred in an irregular manner. Strain gauge readings indicated that, while the average stress in all bars was within 50 lb. per. sq. in. of the calculated stress, there was considerable variation between individual bars, which must cause some error in arch ring moments and stress calculations. It is felt that some modification in design or construction methods to avoid this uncertainty is worthy of attention for future design.

### Floor System

The floor system is of usual design, but over the arch spans, due to the fact that the floor beams were poured some time before the slab, and also as it was advisable to have T-beam action, horizontal shear keys 3½ in. by 8 in. by 8 in. were provided at 16-in. centres between the stem of the floor beam and the slab to take care of horizontal shear.

One-quarter of the total negative steel was run continuously through the top of the slab to care for tension

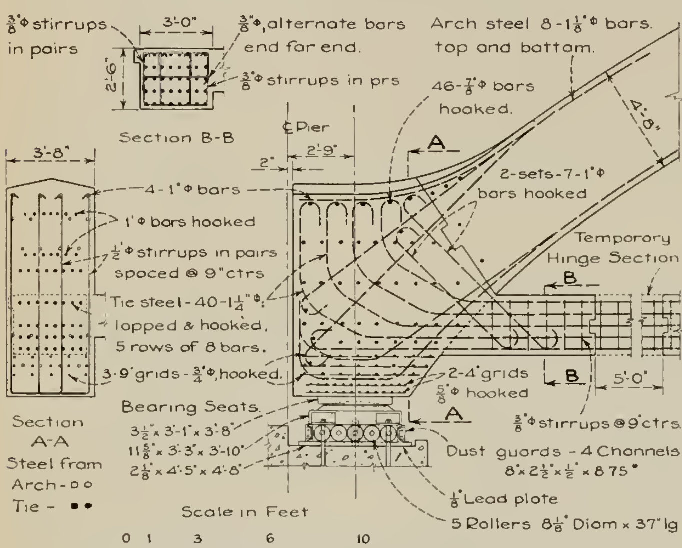



Fig. 7—Detail of Terminal Block.

which might be developed due to elastic extension of the ties under live loads. Actually, due to the deferred tie elongation mentioned above, much greater tension developed and transverse hair cracks appeared in the slab at the panel third points where the top steel was bent down. It is felt that as time will not normally permit a delay in pouring the slab until tie elongation has reached equilibrium, further provision should be made to take care of longitudinal tension in the slab.

## II. MEASUREMENTS AND EXPERIMENTAL DATA ON ACTUAL BEHAVIOUR OF THE STRUCTURE

As little experimental data on the actual behaviour of temporary hinges under such conditions could be found

Fig. 8—Terminal Block Reinforcement.

in engineering literature, it was decided to take strain gauge readings to determine rotations at the hinges, and, by recording temperatures and crown deflections, to determine approximately what percentage of the potential moment due to tie elongation, concrete shrinkage, arch

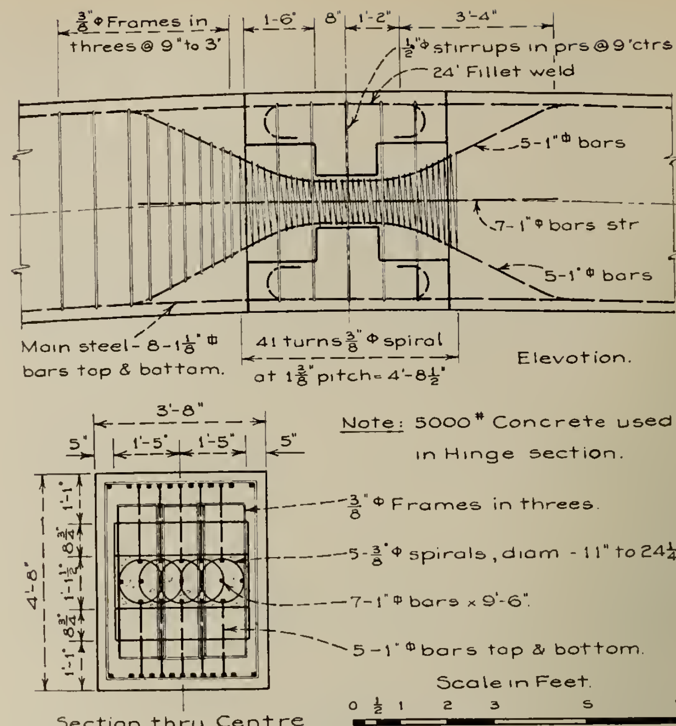



Fig. 9—Details of Crown Hinge.

shortening and temperature drop was eliminated and what maximum stresses were reached in the hinge. Unfortunately due to lack of previous experience with such structures and the need for haste in completing all concrete work in the face of the rapidly approaching low fall temperatures, the readings were neither as complete or extensive as desirable, but several hundred readings were taken and it is felt they do throw sufficient light on the behaviour of such hinges to warrant presentation in detail.

The hinge design is shown in detail in Fig. 9 and the reinforcement and hinge as constructed are illustrated in photographs in Figs. 10, 11 and 12. The hinge is of the modified Considere type with the main arch steel discontinuous until made continuous by welding just before the hinge was concreted in. This type has been used extensively in Europe and in several structures by McCullough[4] in America, and consists essentially of short, closely spiralled and interlocked columns, which when subjected to high direct stresses are supposed to be comparatively flexible and capable of relieving most of the moments in the heavier arch rib sections. It is evident that such a hinge cannot remove all moments and it is equally evident that a theoretical analysis of the percentage removed is uncertain and involved, and experimental work on this problem seems desirable.

To obtain crown rotations and hinge moments and stresses, five gauge lines were established by setting steel plugs 20 inches apart in the concrete as indicated in Fig. 13; the measurements on gauge lines 1 and 5 were used to determine crown rotations, while the hinge moments and stresses were calculated from measurements on lines 2, 3 and 4. All measurements were read by means of a strain gauge reading to 1/5000 of an inch.

The rotations at the terminal blocks were determined by measuring the distance between two points, one on the top movable plate of the spherical bearing, the other on the bed plate. Measurements were made by means of an inside micrometer gauge reading to 1/1000 of an inch.

Vertical deflections of the crown were read by means of an accurate level reading to the nearest 1/100 of an inch.

Temperature measurements were made by resistance thermometers buried in the concrete when poured. These thermometers were made of 500 ohm telephone coils inserted in a ¾ in. steel tube 7 in. long and well sealed with a hot solution of paraffin and rosin in equal parts. Short leads of rubber-covered mine cable were attached and readings taken with a portable Wheatstone bridge. All coils were carefully calibrated before placing and an accuracy of ½ deg. F. was obtained. Such thermometers were placed at the third points in all arch rings, in the horizontal ties and road slabs, and the leads from all thermometers in span 6 were wired to a permanent location, so that temperature records might be taken during the following year; later in this paper a graph of the temperature variations in this series through the winter of 1936-37 will be shown. In addition, careful readings were kept of the temperatures in the crown hinges by means of mercury thermometers inserted into holes in the hinges, these records were used in correcting the strain gauge measurements.

### Behaviour of Span as a Three-hinged Arch

The question of fundamental interest in connection with the temporary crown hinge is: To what extent does this element permit the behaviour of the arch ring during construction to approach that of an ideal three-hinged arch? Three different methods of approach to the solution are presented, of which the last is the most dependable. First, the observed vertical deflection of the crown can be compared with the theoretically calculated value for a perfect three-hinged arch. Secondly, the calculated rotations that would occur at the crown for a three-hinged arch can be compared with the observed rotations. Thirdly, the residual moment carried by the hinge can be measured and thus an estimate obtained of the percentage reduction in the potential arch ring moment. The first two methods will be discussed briefly and the third, which is more illuminating, examined in detail.

The measured deflection of the arch crown on decentring was 1.15 in. which would correspond to an effective change in span length of 0.93 in. The calculated change found by adding the measured horizontal tie elongation of 0.55 in. to the calculated elongations due to arch shortening, concrete shrinkage and temperature drop in the rib amounts to 1.21 in. The difference of 0.28 in. is probably due to the uncertainties surrounding the assumptions of shrinkage and temperature effects during the early curing period. The thermal coefficient of green concrete is probably lower than 0.000006, which was used in the calculations, and, as the temperature drop during the period from September 29th to October 8th was 26 deg., an error of relatively large magnitude is possible in this factor. Again the assumed coefficient of shrinkage, 0.00004, during the first ten days is subject to question. In any event, the above method indicates that the deflection is at least 80 per cent of that indicated for a perfect three-hinged arch at the end of ten days, and other data point quite clearly to the fact that the correspondence became closer with time.

Fig. 10—Hinge Reinforcement.

In applying the second test, it should be noted that the total crown rotations should be twice those at the springing. Actual observations showed that rotations occurred as expected but at the springing they were more irregular and lagged several days behind those at the crown. The maximum crown rotation of 0.002 radians occurred immediately after the arch ring was decentred. When the floor system was struck the rotation was reduced to 0.0013 radians, which was due to decrease in dead load eccentricity at the crown and probably some stress adjustment in the hinge. The theoretical rotation for perfect articulation for this later condition is 0.0018 radians. The rotation at the springing, which immediately after the arch ring was decentred measured only 0.0004 radians, increased later on to 0.001 radians. Part of this increase is probably due to further extension of the elastic tie after the closure of the crown hinge. The observed rotations at the crown suggest that the structure was behaving substantially as a three-hinged arch.

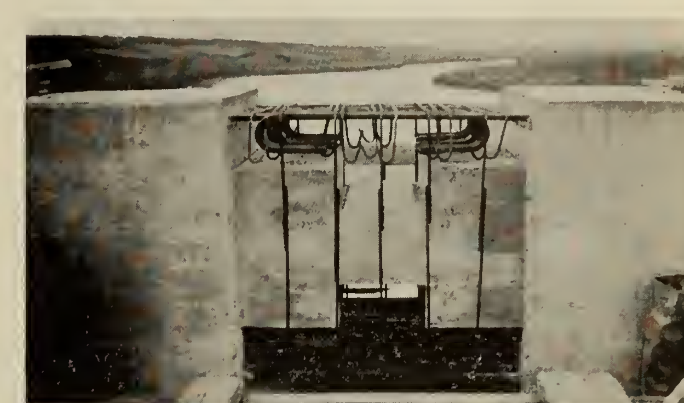


Fig. 11—Hinge, showing Main Rib Reinforcement.

Fig. 12—Arch Ring with Hinge in Place.

A very interesting observation was made on the effect of leaving the last panels of the horizontal tie unconcreted until final closure. At one end of span 4, in order to make the supports more rigid over the long spliced falsework piles, the end panels were concreted before the arch ring was poured. The resultant rotations at this end were only about 70 per cent of those at the other end. Calculations on the basis that both ends had been so concreted show that the arch rib stresses would have been increased thereby only 30 lb. per. sq. in. and one might question the value of providing this extra flexibility at a joint which functions quite well without it. The assumption that after final closure the structure will act approximately as a two-hinged arch was incidentally also verified.

### Actual Moments and Stresses in Crown Hinge

The third and most dependable test was based on strain gauge measurements at the crown hinge. In determining stresses from strain measurements, particularly if these be large, knowledge of the exact elastic behaviour of concrete of that particular strength and age is essential. Consequently, cylinders of similar strength of concrete to that used in the hinge were made and stress strain curves obtained for an age and strength comparable to those of the hinge concrete when strain measurements were being made, and these curves were used for all determinations of stresses from measured strains.

As concrete shrinkage deformations also enter into stress calculations an attempt was made to determine the shrinkage coefficient by strain gauge measurements at the extrados, intrados and axis lines of the arch rib at the quarter point before decentring the rib. Considerable difficulty and uncertainty were experienced in interpreting the results obtained due to the large variation and changes of temperature in the ring and to the fact that shrinkage along the extrados appeared to be about twice as great as that at the intrados. However, it is felt that an average value of 0.00004 for the coefficient for the first ten days after pouring can be taken as reasonably correct.

The first strain gauge measurements were taken on the hinge of span 6 and the experience so gained suggested certain beneficial modifications which were adopted for the other two spans. While data are available for all spans the following discussion, for the sake of brevity, will be restricted to observations on span 5.

The strain gauge points were placed in the hinge of span 5 two days after the arch ring pour had been completed. At this time three vertical tension hair cracks were noticed at the ends and centre of the top half of the reduced hinge section, and these cracks made difficult the interpretation of strain gauge readings on gauge line 2. It was believed at first that these cracks which appeared on all hinges, were developed by negative bending moments

Table IV
Temporary Arch Crown Hinge Rotations, Deformations and Stresses

| Date | Construction conditions | Measured rotation of hinge in radians (1) | Gauge line No. | Corrected apparent deformations in 20-in. gauge length | Apparent concrete stresses lb. per sq. in. obtained from stress-strain curve | Calculated average D. L. stresses and deformations |
|---|---|---|---|---|---|---|
| Sept. 25<br>Sept. 26<br>Sept. 28 | Arch hinge poured.<br>Arch ring completed.<br>Initial readings taken. | | | | (2) | |
| Sept. 29 | Arch ring, sway bracing and tie supported. | − .00004 | 2<br>3<br>4 | + .0016<br>+ .0010<br>+ .0008 | + 200<br>+ 125<br>+ 100 | |
| Oct. 1 | Ditto | + .00040 | 2<br>3<br>4 | (3)<br>+ .0019<br>+ .0031 | <br>+ 260<br>+ 430 | |
| Oct. 2 | Ditto | + .00033 | 2<br>3<br>4 | (3)<br>+ .0010<br>+ .0026 | <br>+ 150<br>+ 390 | |
| Oct. 6 | Ditto | + .00043 | 2<br>3<br>4 | (3)<br>+ .0009<br>+ .0027 | <br>+ 160<br>+ 470 | |
| Oct. 7 | Ditto | + 00044 | 2<br>3<br>4 | − .0012<br>− .0006<br>+ .0010 | − 210<br>− 105<br>+ 175 | |
| Oct. 8 | Sway bracing struck. | + .00039 | 2<br>3<br>4 | − .0022<br>− .0012<br>+ .0002 | − 380<br>− 200<br>+ 40 | |
| Oct. 8 | Arch ring and sway bracing struck. | + .00200 | 2<br>3<br>4 | − .0138<br>− .0040<br>+ .0040 | − 2440<br>− 680<br>+ 680 | Stress − 710<br>Deformation .0042 |
| Oct. 9 | Arch ring, sway bracing and tie struck. | + .00133 | 2<br>3<br>4 | − .0152<br>− .0090<br>− .0034 | − 2680<br>− 1580<br>− 580 | Stress − 1300<br>Deformation .0075 |
| Oct. 10 | Road slab poured. | | | | | |
| Oct. 16 | Hinge steel welded after readings were taken. | + .00122 | 2<br>3<br>4 | − .0178<br>− .0108<br>− .0081 | − 3080<br>− 1900<br>− 1400 | Stress − 1350<br>Deformation .0077 |
| Oct. 19 | Ditto | + .00120 | 2<br>3<br>4 | − .0184<br>− .0110<br>− .0088 | − 3160<br>− 1940<br>− 1540 | |

(1) Rotation determined from gauge lines 1 and 5.
(2) Initial tension not known.
(3) Tension cracks not closed, readings meaningless.

caused by the settlement of the falsework under the ring sections adjacent to the hinge, but subsequent observations pointed to shrinkage as the cause.

The gauge readings on the third day after pouring of the arch showed that the hinge section had elongated appreciably in twenty-four hours. The apparent concrete stresses varied from 100 to 200 lb. per. sq. in.; unfortunately these records do not indicate how much extra elongation was developed during the first two days, but there is little doubt that the entire arch ring was in tension caused by concrete shrinkage. The fact that at the quarter points the shrinkage at the extrados was twice as great as at the intrados suggests that the cracks referred to above were caused by shrinkage. At the end of six days extensometer readings on the top layer of the exposed bars of the horizontal tie showed these bars to be in compression to the extent of 2,700 lb. per. sq. in., but unfortunately arrangements had not been made to obtain measurements on the lower layers. It was at first thought that this compression was uniform throughout the tie section and was caused by the horizontal component of the tension in the rib due to shrinkage. Subsequent study, however, led to the belief that the above-mentioned stresses were caused in the main by a bending moment arising out of an upward vertical force at the supports and a downward deflection of the central falsework, both of which were due to the shrinkage tension in the rib. Possibly there was also direct compression of a small magnitude in the tie but without the necessary records it is unfortunately impossible to proportion or evaluate these factors. It is also believed that the tension of appreciable magnitude which, it is known, developed at the crown hinge was much greater in the central than in the springing sections of the arch rib.

During the following eight days from September 29th to October 7th the settlement of the falsework developed a positive moment in the hinge as indicated in Table IV and Fig. 13.

Until the extrados of the hinge was under sufficient compression to close the tension cracks, the measured deformations were not due to concrete stresses but to stresses and adjustments in the top longitudinal steel. Observations and calculations indicated that these tension cracks opened up a maximum total distance of 0.0002 in. and strain gauge readings were corrected by this amount before using them in moment and stress calculations. Table IV gives the observed hinge deformations corrected for temperature, shrinkage and cracks, together with the stresses as obtained from the appropriate stress-strain curve. Figure 13 shows in graphical form the same data and Table V gives a convenient summary of the data and stresses calculated therefrom.

On October 8th, when the arch ring falsework was struck, the largest rotation, 0.002 radians, was observed: That the rotation should have been a maximum at this time, before the dead load of the floor system was being carried, is indicated theoretically. As the function of the hinge is to remove the moment that would have existed had the hinge not been used, that moment for the above conditions was calculated and found to be + 500,000 ft. lb., due to dead load eccentricity, tie extension, drop in arch temperature and concrete shrinkage. The calculated moment in the hinge at this time was + 200,000 ft. lb., the thrust eccentricity having been reduced from 1.25 to 0.50 ft. by the hinge. The theoretical direct stress was 710 lb. per. sq. in., as compared with an apparent value of 680 lb. per. sq. in., and the stress distribution across the hinge section for this condition was nearly planar. It seems that the hinge removed only about 60 per cent of the potential moment at this time.

When the floor system was decentred, the hinge rotation decreased to a value of 0.0013 radians and its

Table V
Extensions, Rotations, Stresses
Summary

| Condition | Three-hinged arch during construction | | Two-hinged arch |
|---|---|---|---|
| | Actual | Theoretical | Theoretical |
| Dead load extension of tie in inches | | | |
| Immediate—3-hinge condition... | 0.55 in. | 0.97 in. | |
| Final —2-hinge condition... | 1.08 in. | 1.27 in. | 1.26 in. |
| Vertical deflection $\Delta r$ of arch crown in inches.......... | 1.15 in. | 1.50 in. | 1.02 in. |
| Rotation in radians for $\Delta r = 1.15$ in. | | | |
| Crown hinge— | | | |
| Arch struck.......... | 0.0020 | | |
| Arch and tie struck.......... | 0.0013 | 0.0018 | None |
| Springing hinge— | | | |
| Arch struck.......... | 0.0004 | | |
| Arch and tie struck.......... | 0.0008 | 0.0009 | 0.0013 |
| Maximum concrete stresses—lb. per sq. in. | | | |
| Crown.......... | 760 | 705 | 930 |
| ¼ point.......... | 915 | 862 | 1075 |
| Stresses relieved by temporary crown hinge | | | |
| Crown.......... | 170 | 225 | |
| ¼ point.......... | 160 | 213 | |

moment to + 100,000 ft. lb., with an apparent direct stress of 1,580 lb. per. sq. in., compared with a calculated value of 1,300 lb. per sq. in., the distribution of the stress appearing to be approximately planar. The above decrease in rotation and apparent moment was caused by the diminishing dead

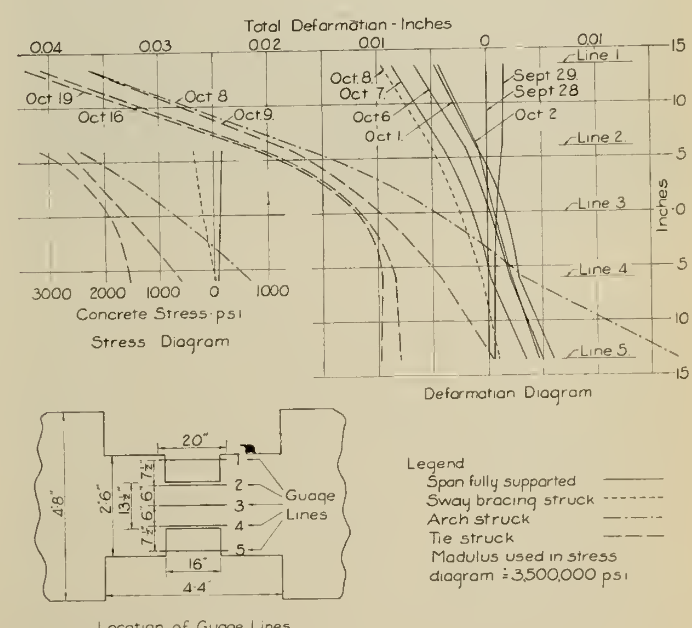



**Fig. 13—Hinge Deformations and Stresses.**

load eccentricity with the application of the floor load. One week later, under the same load conditions, the rotation had decreased again slightly to 0.0012 radians, but an appreciable stress adjustment appeared to have taken place with a parabolic distribution evident, this adjustment tended to equalize the stresses over the hinge section.

It is believed that the largest concrete stresses in the hinge did not occur with maximum deformations, but that greatest stress at the extrados was about 2,550 lb.

per sq. in., approximately double the calculated average direct stress. The maximum stress determined by later strain deformations is 3,160 lb. per sq. in., but it seems certain that these were never realized and that plastic flow produced the additional deformations. The calculated average plastic flow between the 9th and 16th of October is 0.0030 in. in the 20-in. gauge length. This corresponds to a unit flow of 0.00015 in. under a direct load of 1,350 lb. per sq. in., sustained for seven days and is in harmony with the findings of Davis and Davis.[8]

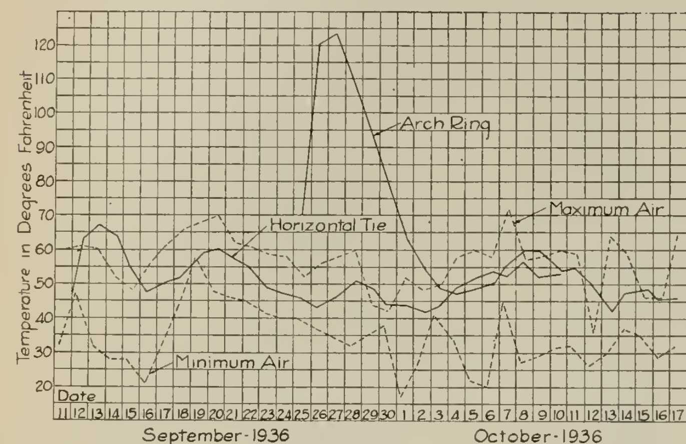



**Fig. 14—Temperatures in Main Members during Construction.**

In view of the large stress adjustment or plastic flow which seems to have taken place, it would appear that the longitudinal steel near the intrados and extrados must have taken additional stress and therefore be responsible for a major portion of the residual moment in the hinge as the steel could not suffer any appreciable bond failure. For this reason it is felt that it might be better design to concentrate most of the steel near the axis in hinges of this type.

Probably the matter of greatest interest and importance is the magnitude of the residual moment in the hinge at closure. The maximum possible value of this moment as calculated from the stress diagram without any allowance for plastic deformation is 87,000 ft. lb. When corrections for such deformations are made the moment is reduced to 44,000 ft. lb. with a thrust eccentricity of 0.66 in. Under similar load conditions the moment at the crown for a two-hinged arch would have been 370,000 ft. lb., so it is seen that the temporary crown hinge actually relieved about 88 per cent of the potential moment and that until closure the structure acted substantially as a three-hinged arch. The moment relieved would have been even greater had it been feasible to delay closure for a longer time, but it is estimated that under the existing circumstances the hinge decreased the concrete stresses 160 lb. per sq. in. at the quarter points and 170 lb. per sq. in. at the crown of the arch rings, a very considerable reduction amounting to about 20 per cent of the maximum stresses.

The residual moment in the hinge causes a stress of only 20 lb. per sq. in. in the arch rib and this could have been theoretically eliminated by placing the hinge axis 0.66 in. below the arch axis, but this eccentricity is not of much significance in a ring of such depth.

*Temperature Records*

As has been stated, temperature records in the various members were obtained immediately after pouring and during the subsequent winter. Figure 14 shows the temperature variations that occurred in the arch ring and horizontal tie for the first few days after completion and indicates clearly the difference in rib and tie temperatures at decentring, which must be taken into consideration in the calculations previously mentioned. Figure 15 is a graph of the temperature variations during a particularly cold period in the winter of 1936-37 and suggest that, if summer temperatures do not go above 100 deg. F., which is unlikely, the assumed design figure of 130 deg. F. for the general temperature range was reasonable.

## III. CONSTRUCTION

The construction programme covered approximately one calendar year. While the contract was signed in October, 1935, it was November before the work was in full swing, as the contractor had to erect boarding accommodation for the men, carpenter and blacksmith shops and engineers' quarters before active operations could commence due to the fact that the bridge site is seven miles from the nearest small town and forty miles from the nearest city. In November, 1936, the bridge was opened for traffic.

The yearly climatic cycle made it imperative to construct the river piers and most of the other sub-structure during the winter months in order that the main superstructure could be completed during the four months intervening between the high water stages in June and the freeze-up in October. Fortunately, the river levels are at their lowest during January and February, which helped to offset the additional costs incurred due to the low temperatures experienced during these months. The work naturally fell into three periods. During the six months that the river was frozen over, October to April, the river and east shore piers were completed. During the period between spring break-up and high-water in June the west pier, column foundations, abutment and girder spans were constructed, while in the remaining four months the three long river spans were built in their entirety.

### Sub-structure

The difficult river piers were constructed during one of the coldest winters on record for this locality, when for fifty-eight days the minimum daily temperatures were below zero F. continually, and for twenty-seven days below −25 deg. F., with ten days below −40 deg. F. When it is

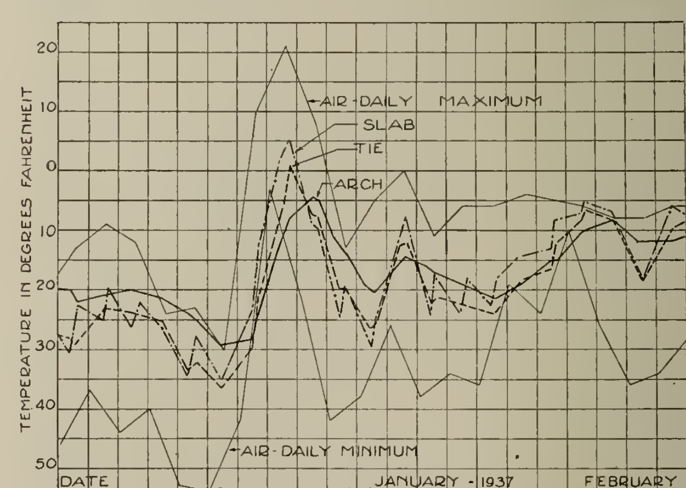



**Fig. 15—Temperatures in Members during Winter 1936-1937.**

realized that during all this time work was carried on continuously during twenty-four hours each day with no rest for Sundays or holidays, and that excavation, pile driving and concrete work had to be done under these conditions, the severity of the working conditions will be appreciated.

During the fall months of 1935, pier 4 and abutment 2 on the east shore were constructed without difficulty. Concreting of pier 4 was finished in November and, while air temperatures varied from 20 deg. above to 10 deg.

[8]Journal American Concrete Institute, March, 1931.

below zero F., no protection was used other than heating the mixing water and aggregate. Thermometers located just inside the forms indicated that the temperatures remained above 40 deg. for ten days, and in the centre of the piers temperatures were over 60 deg. for twenty days.

The concrete mixing plant for all the units, excepting those on the west shore, was located on the east bank at the bridge floor level. The mixers were housed in, as also was the coarse aggregate stock pile, which was placed over a steam pipe grid consisting of 1¼ in. pipes on 24-in. centres with the maximum depth of pile about six feet; a steam tractor was used for heating. The sand was heated in the open by means of several movable steam jets placed in the stock pile; this method proved the best of several tried. An ingenious method, both satisfactory and economical, of heating the mixing water was used. A small steam pump delivered water under pressure to a vertical boiler which raised the water temperature up to 100 deg. or more. An air compressor maintained air, in the upper portion of the boiler, in sufficient volume and pressure to supply hot water at a uniform rate to the mixers.

In the extreme cold weather it was difficult to obtain uniform temperatures in the coarse aggregate pile and steam jets were used as an aid. The sand, although unprotected, heated more uniformly and retained its heat longer, and jets operated for two days before pouring kept the sand pile at temperatures between 100 deg. and 150 deg. F. Temperatures of the resulting concrete coming out of the mixers were watched very carefully and were maintained at from 70 deg. to 90 deg. F.

The concrete was wheeled to the river piers on a trestle built to the pier top level; men wheeled the buggies up to a maximum distance of 500 ft. on this unprotected runway 35 ft. above a wind-swept river for twenty-four hours a day with the thermometer approaching 50 deg. below zero. Figure 16 is a view taken during the concreting of pier 3, the men and buggies are clearly seen on the runway; the picture was taken February 8th, 1936, the official temperature reading at the time being 45 deg. below zero. The buggies were dumped into steel chutes which discharged into the pier and when things went well the concrete reached its destination with very little loss in temperature, but when, as sometimes happened, a temporary clogging of the chute occurred, if it could not be cleared by hammers immediately, the concrete in the chute and in the waiting buggies would freeze solidly and concreting would have to be suspended until the chutes and buggies were cleared with steam jets. Even during the periods of extreme cold weather no outside protection of the concrete in the piers, other than the forms, was used, but as soon as a pour was finished the surface was covered with tarpaulins and shiplap and steam jets used under the covering until the next pour started, just before which the covering was removed and the surface of the concrete picked, wire brushed and cleaned. Temperatures were taken in the piers continuously, and generally after dropping to about 60 deg. the heat of setting would force the temperature up to 140 deg. in two or three days, after which it would fall gradually down to 32 deg. in ten to fifteen days. Thermometers placed directly inside the forms showed that even at the surface the concrete temperatures stayed well above freezing for ten days. The resulting concrete in all piers was excellent, as shown in Fig. 17.

While the concreting of the two river piers during the extremely cold weather of January and February demanded constant care, the construction of the cofferdams, the excavating and driving of bearing piles, were by far the most difficult and strenuous of all the operations. Work was carried on in three shifts day and night, and at many times workmen would be standing in 18 in. of water, shovelling sand, with air temperatures around 40 below, and everything covered with ice. Again, excavation would be proceeding at one end of the cofferdam while bearing piles were being driven at the other end, the steam from the hammer would fill the air with mist and during the night, even with numerous lights, the danger and exposure of such work were extreme and great credit is due to the courage and tenacity of the local farmers, inexperienced in such work, who cheerfully took this opportunity of avoiding the alternative "relief."

**Fig. 16—Cold Weather Concreting.**

**Fig. 17—Pier 3 and Ice "break up."**

On pier 3 the contractor decided to use a double row of wooden sheet piling with clay puddle wall for the cofferdam, and as the depth of the pier base was 27 ft. below the ice level in the river, the pressures made the problem a difficult one under the best conditions. A stratum of large boulders at the river level accentuated the difficulty and many of the piles could not be driven until the dam was unwatered, the excavation carried down, and the boulders removed. When the excavation was within six feet of grade, a stratum of quicksand was struck in the clay and a serious blow-in filled the dam, washing in several hundred cubic yards of material and carrying away one-third of the puddle wall. A large depression 8 ft. deep was created in the river bed and a third row of longer sheet piling had to be driven along one side. One of the expensive items was clay puddle, as all spoil banks and natural soil beds were frozen to depths of 4 to 8 ft. and had to be laboriously thawed by steam jets before removing. When the bottom was within 4 ft. of grade, three distinctly different types of material showed over the foundation base; at one end there was a hard shale-like material, at the other end, a soft plastic blue clay, while in one corner there was a large pocket of quicksand which caused endless worry and expense due to the constant threat of "blowing." While the excavation was still 4 ft. from grade, the bearing piles were driven to lessen the danger of blow-ins and to reduce the pressure on the cofferdam during pile driving. The remaining excavation was removed in sections and the concrete mat poured. Drains had to be constructed through the concrete mat to a central sump to care for numerous leaks that threatened to leach the freshly deposited concrete.

The cofferdam at pier 2 where the water was 13 ft. deep consisted of a single row of 38-ft. Algoma steel sheet piling, driven into the clay to a distance of 6 ft. below the pier base. As this dam was not started until February 11th, time was a pressing factor and every effort was made to avoid delays. The piles were all set in place resting on the river bottom and supported by two frames, one on the ice and the other 15 ft. above it, and each pile was carefully plumbed in two directions, with the result that closure was made without any difficulty whatsoever. After the piles were driven, when the leakage at interlocking joints made it impossible to lower the water level when pumping at a rate of 2,000 gallons per minute, the contractor adopted a novel and inexpensive method. Large panels of shiplap were dropped around the outside of the piling and the spaces formed by the inset portion of the steel piling and the panels filled with straw manure. When pumping was again started the filling material sealed the leaks and the dam was readily dewatered, the pressure difference then tightened the joints and little further trouble was experienced.

No special difficulties were found in excavating through the 14 ft. of sand and clay to the pier base, but during driving of the bearing piles great pressures were developed on the cantilevered portion of the steel piles below the lowest wale, due to vibration and unbalanced earth pressures. The bottom wales were made of new 14 in. by 16 in. fir and the struts, which were 10 ft. by 10 in., were on 8 ft. 3 in. centres; the great pressures caused indentations of struts into wales of over 1 in. and it was thought advisable to put in a second system of wales and struts before completing the driving.

The cofferdam bracing was designed with sufficient strength to permit the removal of the timber work as concreting proceeded without restrutting the cofferdam to the pier concrete, thus eliminating a delay that could be ill afforded. A point worth mentioning is the fact that in all cofferdams the timber bracing is subject to the greatest stresses when the lower systems are being removed as the pier forms are built up.

The foundation piles in the river piers were driven by a 5,500-lb. Union steam hammer operated in swinging leads, the piles were 30 ft. in length and driving finished at from four to twenty blows to the inch. In pier 2, 225 piles were driven in five and a half days of continuous work. Concreting on that pier was finished on April 1st and the ice in the river broke up on April 19th. Although the break up was unusually violent and the flow of ice heavy, no abrasion was evident on the noses of the ice breakers, although these were not protected by steel of any kind, the concrete merely being made richer in these portions by puddling extra cement into the concrete, as placed. Figure 17 gives an idea of the nature of the ice flow at "break-up" and the thickness of the ice which in the winter measured 46 in.

The foundations for pier 1 and the bents on the sand bar at the west end were constructed during the spring months after the ice went out, although some preliminary work was done on the pier cofferdam in November, 1935. These foundations were all in fine river sand and the piers rested on bearing piles driven to the clay stratum about 50 ft. below water level. In such cases, it has generally been assumed that it is important to drive the sheeting a sufficient distance below the foundation base in order to prevent blow-ups inside the cofferdam as the excavation approaches the design levels. For the bent footings, circular cribs, 17 ft. in diameter, were constructed of 6-in. by 12-ft. tongue and grooved fir sheet piling. The cribs were driven 11 to 12 ft. below the base of the foundation, but even then considerable difficulty was encountered as the sand gave definite evidences of approaching instability when the excavation approached the final elevations. Preliminary calculations were made to determine the probable rate of flow into the cribs of bent 2 on the assumption that the ordinary principles of the hydraulics of shallow wells would be applicable. The sand was found to have an effective size of 0.12 m.m. and a porosity of about 35 per cent, the sand stratum was assumed to be 50 ft. in depth and it was assumed that water would flow to the crib well from all sides and the radius of the circle of influence would be 100 ft., the approximate distance to the river line. On this basis and with the water level in the crib drawn down 20 ft. it was calculated that there would be a flow of approximately 20,000 gallons per hour. Actually the measured flow was about 25,000 gallons per hour and while this appears to be a good check it should be realized that the many assumptions necessary in such calculations subject the method to potentially large errors. It will also be noted that the theoretical flow is not influenced at all by the distance the sheeting extends below the foundation base. It would seem, therefore, that, provided the sheeting has watertight walls and extends far enough below the foundation base to prevent the sand being forced directly into the excavation zone in a horizontal direction, there is no great benefit to be derived from further depths. What the proper depth is cannot be determined theoretically but experience would suggest that for such conditions as were found on this job a maximum distance of 9 to 10 ft. below the excavation level is sufficient. Providing that the cribbing has been driven properly, it would seem that the conditions for success would be that the upward vertical velocity of the water in the casing should not exceed the hydraulic subsiding value of the fine particles of the sand, but here again theoretical calculations are not reliable because the flow is not uniform and "boils" occur over the area; this was particularly evident in the larger excavation for pier 1. However, the empirical data obtained on bent 2 are valuable, where it was found that with an average upward velocity of 2.5 ft. per min. calculated on the gross cross sectional area, sands of 0.12 m.m. effective size are approaching the limit of stability. It will be further realized that had these small bent footings been carried much deeper, other methods of construction would have been necessary. An interesting and practically useful observation was made in connection with "boils" in all sand excavations; it was found that such boils seemed to depend on the gradual and progressive opening up of small channels in the sand and that, if the excavation were allowed to fill up with water when stability was threatened, these channels were blocked again and after dewatering excavation could be carried on for a time with no signs of dangerous "boils."

The foundation for pier 1 was taken to a depth 23 ft. below the water level, or 3 ft. lower than that for the bents. The cofferdam, 26 ft. by 70 ft. in plan, was constructed of wooden sheet piling driven 9 ft. below the pier base, and while the total inflow was much greater, the rate of flow per unit area was much less and the sand consequently more stable.

If the excavation within the cofferdam of pier 1 be considered as a gallery with water flowing in from both sides under a head of 23 ft. and if the distance "$R$," from the edge of the gallery to the line where the ground water level can be considered as unaffected by the flow, is taken as 10 ft, then hydraulic calculations will indicate that the rate of flow into the excavation when it is dewatered should be 4 to 5 times that for the column crib and, as the area of the former is about 8 times the latter, less trouble from unstable sand would be anticipated and this, as stated above, proved to be the case. The interesting conclusion, which of course is apparent on reflection but frequently overlooked, is that in such cofferdams in sand, if taken to the same depth, the smaller the area the more trouble will be experienced.

All of the sheet and bearing piles on these units were driven easily with the aid of a water jet consisting of a 1½-in. jet on the end of a 2½-in. pipe, supplied with water from a steam pump at the rate of 250 gallons per minute, under a pressure of 60 lb. per sq. in. at the nozzle. A steam hammer was used, but light driving only was necessary until the piles were within 8 ft. of their final location, when the jet was removed and the hammer used alone.

### Superstructure

During construction, the bow-string spans demanded constant attention and careful inspection, but were finished without mishap. Driving of falsework piling was started about the middle of July and within four months the bridge was opened for traffic; the first concrete was poured on August 17th and the slab of the last arch of the three was finished October 29th. Due to the cold weather at that time, the concreting of the vertical hangers was deferred until the spring of 1937.

The falsework piles in the river were driven with a 2,600-lb. drop hammer operated on a scow which was held by a cable suspended right across the river. A small gasoline hoisting engine operated the hammer and the entire layout proved flexible and efficient and more convenient and economical than the steam hammer. The piles were driven readily 15 to 25 ft. into the river bed without the use of jets. The driving was constantly watched by an engineer inspector and all piles driven to a penetration corresponding to a safe bearing value of 10 tons by the Engineering News formula. Where erosion had occurred around pier 2, piles were driven through 28 ft. of water, 50-ft. piles were used spliced by pipe sleeves 12 in. in diameter and 24 in. long. The average load per pile

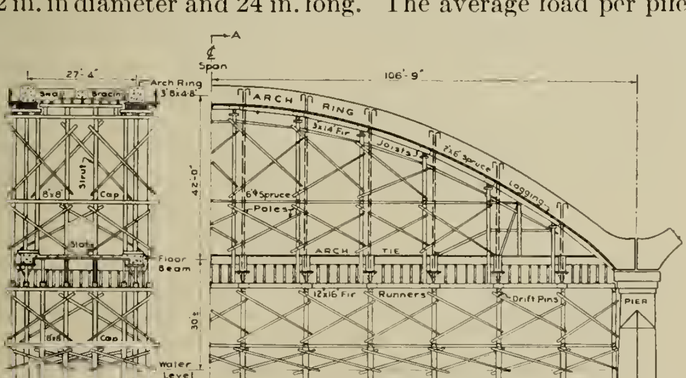



Fig. 18—Falsework for Bowstring Spans.

in each bent was 14 tons, and, while some individual piles carried 18 tons, careful levels kept on the piles during concreting operations showed that no settlement over 1/8 in. occurred anywhere.

The piles were Saskatchewan spruce, 40 ft. in length with an average butt diameter of 14 in. The piling and falsework were braced with 3 in. spruce poles. Figure 18 shows clearly the arrangement of falsework. Under each floor beam a bent of eight piles was driven and capped. Above this a second system of bents was erected, which supported directly the floor system and horizontal tie forms. A third and fourth system of bents were erected above, but offset 2 ft. to clear the floor beam forms. These latter bents after capping carried directly the 3 in. by 14 in. joists which were sawed to the proper curves, allowing ½ in. for deflection, to support the arch and sway bracing forms. The forms for the horizontal ties and floor beams were then finished and the concrete poured, after the roadway slab forms had been constructed to serve as a working platform. A section in the end panels of the horizontal tie was left

Fig. 19—Falsework and Forms during Concreting.

unconcreted but the terminal connection between the tie and arch rib was finished with the ties.

After the ties had been poured, the arch ring and sway bracing falsework was finished and, as shown, two of the bent posts supporting the arch rib rested directly on the horizontal tie, thus giving greater uniformity of loading on the pile bents below.

The arch ring joists were lagged with 2-in. by 6-ft. planks spaced on 12-in. centres and the form bottoms consisted of 1-in. by 4-in. matched spruce flooring laid longitudinally and bent to a smooth curve which gave a perfectly curved surface that was easily rubbed.

Before the ribs were poured, the floor beam supports were struck in order to relieve any possible negative moments in these members due to slight settlement of the arch falsework. The arch ribs and sway bracing were poured together, the rib in sections as shown in Fig. 6 and the central panel of the sway bracing was not poured until the arch ring and tie falsework had been struck and the crown deflection realized, otherwise the forces set up during deflection would have caused serious damage to the bracing.

The arch ring, sway bracing and horizontal tie falsework was struck about ten days after the pour was completed, the falsework was then removed over the roadway and this slab completed. After the floor system supports were struck, the main arch reinforcement laps at the crown hinge were welded, and the concreting of the hinge and sway bracing completed.

### Concrete

The coarse aggregate and sand were both of excellent quality, the latter was obtained locally but the former had to be brought in 100 miles by train. The aggregates were measured by volume and careful check was kept on the mixing, allowances being made for bulking of sand and water content in the aggregates. A test cylinder was taken for every 25 cu. yd. poured and unusually uniform and high strengths obtained. Table VI gives a resumé of the proportioning used and the average strengths from over 300 test cylinders.

### Vibration

On all of the superstructure and on part of the substructure concrete vibrators were used. The equipment consisted of two 4-in. diameter electric vibro-spades operated by a portable 1½ kv.a. generator driven by a gasoline engine, manufactured by the Electric Tamper and Equip-

Table VI
Concrete Mixes and Strengths

| Location | Mix by volume | Slump Inches | Water/cement ratio | | Ave. 28-day strength lb. per sq. in. | |
|---|---|---|---|---|---|---|
| | | | Imp. gal. per bag of cement | Bags cement per yd. | Obtained | Designed |
| Piers below elev. 1445 | 1 : 2.6 : 3.8 | 1 | 6 | 5.2 | 3,000 | 2,500 |
| Piers above elev. 1445 | 1 : 2.2 : 3.6 | 1½ | 5¾ | 5.5 | 3,200 | 3,000 |
| Girder spans | 1 : 1.9 : 3.4 | 2 | 5 | 6.2 | 3,600 | 3,000 |
| Arch rings | 1 : 1.7 : 3.0 | 2 | 5 | 6.6 | 3,800 | 3,500 |
| Horizontal ties | 1 : 1.8 : 3.2 | 3 | 5¼ | 6.2 | 3,300 | 3,000 |
| Hinges | 1 : 1.4 : 2.0 | 6 | 4½ | 8.0 | 5,000 | .... |

ment Company. Excellent results were obtained, particularly in the heavily reinforced section where vibration of the reinforcing rods made it possible to use a dry mix that could not otherwise have been placed. Figure 20 shows such concrete being placed in one of the horizontal ties and the manner in which the concrete flowed around the bars can be observed.

The road slab was vibrated by means of a vibro-spade which was dismantled and fastened to a 2-in. by 12-in. plank three feet long. The device was provided with handles and two men operated it easily and satisfactorily.

Vibrators were very useful in placing the foundation mats on the sand foundations where the upward velocity of the water tended to leach the cement out of the concrete. The concrete mix for these mats was harsh and dry and the vibrators compacted it sufficiently to prevent the forming of channels by the rising water. Batches of concrete mixed without any water and vibrated into the placed concrete were found to assist in preventing leaching.

Fig. 20—Concrete Vibrator.

It was found that in mass concrete work the best surface results were obtained by keeping the vibrators a short distance from the forms, as, if operated too closely, grout was driven through the forms and surface pockets formed.

It is believed that vibration effected a saving of about 8 per cent in cement, reduced the cost of placing concrete by 20 cents per yard and eliminated a great deal of expense in patching, provided a strong and homogeneous concrete and gave a uniform and fine appearing concrete surface.

Cold weather was experienced during the pouring of the last arch span. The arch ribs, being of considerable cross section, were protected easily by covering the exposed top surfaces with tar paper and boards, but more difficulty was experienced with the thinner road slab. Two days after the road slab was poured the air temperature had dropped to zero and to 13 deg. below in a week. The temperature in the slab dropped rapidly even though a covering of shavings and boards was used. The slab was then cleared and covered with tarpaulins and steamed for five to six days. Concrete temperatures read by resistance thermometers buried in the concrete, as mentioned in Part II of this paper, enabled an estimate to be made of the curing conditions and when it was determined that 50 per cent of the twenty-eight day strength had been obtained the falsework was struck.

### Settlements

Careful levels were taken during construction to determine settlements of the structure. The calculations and allowances made for falsework settlements checked well with those actually read for all spans. It was found that an average settlement of 1/16 in. per horizontal joint in the falsework was obtained. The following table gives the data recorded for span 5, which are typical of the other spans as well.

Table VII
Settlements of Structure During Construction

| | As recorded |
|---|---|
| Settlement of horizontal tie immediately after concreting | 0.54 in. |
| Further settlement of horizontal tie after arch ring was concreted | 0.58 in. |
| Settlement of falsework between the tie and ring after concreting | 1.00 to 1.50 in. |
| Deflection of arch crown immediately after decentring | 1.15 in. |
| Deflection of horizontal tie at centre after decentring | 1.28 in. |
| Total settlement and deflection of arch crown | 3.23 in. |
| Further deflection of arch crown thirty days after decentring | 0.42 in. |

### Cost Data

The total cost of the bridge was $291,500 of which the substructure accounted for $155,100 and the superstructure $136,400. There were 9,640 barrels of cement, 680 tons of steel and 19,200 ft. of piles used in the job. The excavation totalled 4,500 cu. yd. and the concrete placed 6,500 cu. yd., of which 3,800 cu. yd. were in the substructure and 2,700 in the superstructure.

The following table gives data on unit costs and quantities:

Table VIII
Unit Costs and Quantities

| | |
|---|---|
| Girder Spans:— | |
| Total length | 221.08 ft. |
| Cost per lineal foot | $ 84.41 |
| Cost per square foot (road and sidewalks) | $ 3.33 |
| Concrete per lineal foot | 2.09 cu. yd. |
| Concrete per square foot | 0.08 cu. yd. |
| Reinforcing steel per cubic yard concrete | 205 lb. |
| Arch Spans:— | |
| Length | 623 ft. |
| Cost per lineal foot | $187.20 |
| Cost per square foot (road and sidewalks) | 7.24 |
| Cost per square foot (clear width) | 7.91 |
| Concrete per lineal foot | 3.54 cu. yd. |
| Concrete per square foot | 0.137 cu. yd. |
| Reinforcing steel per cubic yard concrete | 351 lb. |

This project, undertaken as part of the 1935 public work programme of the Federal Government, was under the direction of K. M. Cameron, M.E.I.C., chief engineer, and F. G. Goodspeed, M.E.I.C., district engineer of the Department of Public Works of Canada. The senior author was consulting engineer, responsible for the design and general supervision; the junior author acted as designing engineer and afterwards was engaged by the Department as senior assistant engineer in charge of construction.

# The Characteristics and Application of Modern Electrical Relaying

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**Paper to be presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—A discussion of various types of high speed protective relay equipment for power systems, some problems in design, certain difficulties in operation, and some of the benefits obtained.

A relay, in electrical practice, has been defined as "a device which is operative by the variations in one electric circuit to effect the operation of other devices in the same or another electric circuit." The owner of an early water-wheel driven generator for lighting his property who devised a push button arrangement so that he could shut down the water-wheel when he was ready to go to sleep, made use of a relay circuit to his great convenience. From such early beginnings, the application of relay devices to the control and protection of electrical and other systems has been extended until practically every branch of industry depends for control and safety on varied forms of these devices.

The peculiar susceptibility of electrical energy to control in this way has resulted in many relay and control devices being electrical in character even when not actually applied to electrical circuits. In a paper such as this it will not be possible to discuss all these applications. Attention will, therefore, be devoted chiefly to the field of protective relaying in power supply systems. A brief survey of some of the other fields is included as a matter of interest.

Relays of the control type find a widespread application in industry. More recently older types of relays are being supplemented by various classes of devices of the electron tube type. Equipment of these types in the proper combination can be used for the starting and stopping of motors and other devices, for automatic speed control, for control of sequences in various manufacturing processes and in numerous other ways to promote increased output of and accuracy in the product which cannot be obtained by other means. Examples are to be found in the modern paper and steel industries. In electric welding the rapid fabrication of structures is made possible by accurate control by means of relays and electronic devices; while applications of the photo-electric tube (the "electric eye") are becoming commonplace.

In the field of communication the setting-up of signalling and talking circuits is an important function of relay devices. Such relays are typically compact, reliable, inexpensive and of low energy requirement, so that they can be operated at distances of several miles over light wire pairs in the ordinary telephone cable. Relays of a very similar type are used with such conductors for the remote control of apparatus in electrical supply stations, enabling several such stations to be controlled from a central point.

In cases where the stations are beyond the practical operating range of control over telephone wires, the functions may be performed by high frequency "carrier" currents transmitted over the power wires, so that the range of control is greatly extended. For example in the case of the transmission lines from the Boulder dam to the City of Los Angeles, an installation of control by "carrier" current applied to four conductors of the two main 287 kv. transmission circuits enables the operator at the generating station to control and obtain various indications from the receiving-end station some 270 miles distant, as well as from two intermediate line switching stations.

However, probably the most important form of relay application in the field of electric power generation and supply is that selected as the principal subject of this paper. "Protective relays," as they may be termed, perform the function of automatically ridding the system of any element which has developed an abnormal condition, usually an electrical fault or short circuit, as in the failure of insulation. The feature which characterizes modern practice in protective relaying is the development and growing adoption of methods for very rapid clearance of such faults. This has involved the development of high speed equipment in both relays and circuit breakers, because the total clearance time is the sum of the operating times of these two pieces of equipment.

It is of interest to note that use of most of the characteristic methods of high speed relaying is not new in this part of Canada. Such protective equipment has been advocated and quite extensively applied in Quebec province and to some extent in Ontario in the decade 1920 to 1930 though in conjunction with the standard oil circuit breakers of that period. A number of these installations have been described in papers presented to this Institute. Insofar as this author is aware, however, no other such installations were made up to about 1929.

The earlier standard types of relaying were based on the use of the induction disc relay similar in construction to the familiar watthour meter. The device is basically an inverse time or inverse definite time overcurrent relay, but with special adaptations may be made to function as a directional, current balance or differential relay and as a discriminating relay for voltage, power, frequency or other electrical quantity. It is rugged, accurate and reliable over long periods of hard usage and can be successfully applied in the following cases:—

> Where the relay is required to carry a normal load current into the circuit protected not in excess of one-fourth the minimum sustained current that results from a fault in that section.
>
> Where the relay is not normally affected by load current, that is in differential or balanced connections, or when directionally controlled as at the receiver end of a line; also as a residual current relay for ground fault protection.

In the main high voltage network of most high capacity systems, or in any system where the capacity and loading of the circuits is high in comparison with the generating capacity connected, this type of relaying is clearly inadequate. It is too slow to hold stability between power sources or to prevent damage, and too dependent on connected generation for reliability. In such systems the increasing tendency at present is to adopt high speed methods of fault clearance.

Standard equipment now being offered in relays and oil circuit breakers for circuits of any voltage will clear faulty sections selectively in less than 0.2 sec. as compared to 0.5 to 5 sec. which may be required for selective clearance with the older type. In many cases, the older types of circuit breakers may be rebuilt to this standard at a moderate cost. Special oil circuit breakers are available at extra cost which with standard high speed relays will clear a circuit in less than 0.1 sec.

## CHARACTERISTIC METHODS IN HIGH SPEED PROTECTIVE RELAYING

The usual electrical supply system includes generators, transformer banks, busses, transmission circuits and feeders, each of which is referred to herein as an "element." A fault on any element of the system is detected by the protective relays which automatically open the switching devices to segregate the faulty element from the system. It is characteristic of modern relaying that the relays are arranged so that they are not affected by disturbances occurring anywhere in the system outside the element or elements which they protect.

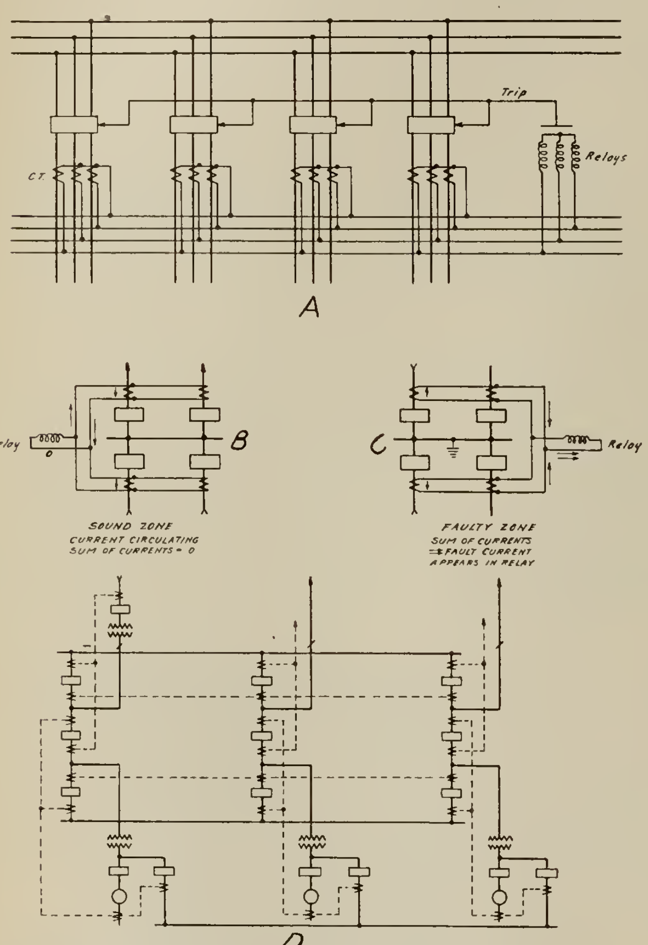


**Fig. 1—Essentials of Zone Differential Protection.**

### Zone Differential Type of Protection

In a generating or distributing station, the busses, station circuits and equipment are usually grouped in a small area, the boundaries of each group being established by oil circuit breakers so that current differential protection can be applied to each group or zone. The essential features of such a protective scheme appear in Fig. 1. This shows *A*, a typical differential connection scheme; *B* and *C*, the principle of operation for sound and faulty zones respectively, and *D*, the wiring diagram of a station with complete zone protection.

While faults on busses are not frequent, they are usually accompanied by heavy fault currents which may cause serious damage and prolonged outage if not quickly cleared. If the failure is in an oil circuit breaker, delayed clearance may result in an oil fire.

### Distance Type of Protection for Transmission Circuits

In the case of transmission circuits, the termini are usually too remote from each other to permit of the use of a simple current differential scheme. For protection of such circuits, stepped-range distance relaying of the impedance or reactance measuring type, with directional characteristic where needed, is widely used. The principles on which this type of relaying is based and the manner in which it is applied are shown in Fig. 2. In this figure, *A* indicates the principles of impedance distance relaying; *B*, the connections of directional impedance relays for phase-to-phase faults; *C*, the application of the stepped ranges of distance relays to line sections of a system, and *D*, the time characteristic of a high-speed distance relay. An instantaneous impedance relay set for a balance point just short of the end of the section to be protected will not be affected by faults beyond its setting and will, therefore, be selective for external faults.

Due to limitations in the accuracy of the equipment, the highest speed of clearance is obtained for faults in about 80 to 90 per cent of the line adjacent to the relaying point. Beyond that point, protection is given by a second relay of similar type which overlaps the other elements of the system but which is delayed in action so as to be time-selective with the instantaneous protections of those sections, providing a back-up effect for faults on a terminal bus or other elements. For more extended back-up effect, a third impedance element of still longer range and longer time delay may be provided.

The time characteristic of a typical high speed element of an impedance relay is shown in Fig. 2D. These relays will operate accurately on values of fault current which, when flowing to a fault at the "remote end" of the line section will produce a voltage at the relaying point of 3 to 5 per cent of the normal value. The minimum effective value of fault current will depend on the impedance of the circuit, but in the case of overhead lines is usually well below normal load except in the case of very short sections. Because of this requirement, however, and because the impedance which may exist in an open arc will be added to the impedance of the line, creating an indeterminate factor for which allowance cannot be made in the relay setting, this type is not applicable to lines of very low impedance.

The impedance relay requires a continuous source of potential representing accurately the primary voltage at the relaying point. Safeguards must be provided against tripping in case of failure of this source.

Impedance relays are not suitable for "tapped" or "branched" lines where there is generation on the branches or where there are high capacity step-down stations; they will, however, function properly with small step-down stations tapped to the line section.

In the impedance form, they may fail to operate on high resistance faults such as those caused by trees over the line, until the resistance has been gradually reduced by charring. As ground relays, they are not very reliable on wood pole lines unless the hardware is grounded.

However, for flashovers, as from lightning or sleet, where the arc strikes cleanly, the impedance type relay is reliable and fast within its range.

They are subject to undesirable tripping when applied to sections of line interconnecting systems and power sources in cases of instability or of wide angular swings approaching instability. In such cases there will be a node of low voltage and high current in one of the tie sections, its location depending on the distribution of the impedance between the power sources. In such cases the impedance relays will operate as though there were a three-phase short circuit at the node and may open the interconnection at an undesirable location.

### Pilot Type Protection for Transmission Circuits

In this type of protection the relay installations at the termini of the circuit are interconnected by a secondary or control circuit so as to give results similar to those obtainable on station zones—namely high speed clearance of any fault in the circuit without danger of tripping for any external condition. This type is theoretically the ideal.

Forms of it have been in use for many years, especially in England and to a much less extent in America. Its development has recently received much attention, so that equipment is now offered which will give very high speeds of complete fault clearance.

Pilot protective schemes differ greatly in details among various installations. For short feeders, the secondary current may be circulated over the pilot between the termini as in the zone differential in a station. In other cases the relays at the termini may be interconnected by a control circuit by which the behaviours of directional elements are compared to determine whether the fault is internal so that tripping should be allowed, or external, in which case the circuit breakers are prevented from tripping. For circuits up to 10 to 12 miles in length this pilot circuit is often a pair of telephone wires, but where the line is much longer, it is usually more economical to utilize a high frequency carrier current system coupled to a conductor of the overhead transmission line. With the carrier system the length of the line protected may be of any length from one mile to 300 miles at about the same cost.

The highest speed carrier pilot schemes offered, while differing in details, have the following in common:—

The carrier equipments at the termini of the protected section are each coupled to the same conductor of the transmission line, which is suitably "trapped" to retain the carrier current on the section. The sending sets, each consisting of an ordinary oscillator tube with amplifiers, are tuned to the same frequency, in the range of 50 to 150 kc. per sec. The filaments are continuously heated, but sets are prevented from generating by a negative grid bias on the oscillator tube.

In the relay equipment at each terminus is a set of sensitive non-directional relays of the impedance type for phase faults and operating on residual current for ground faults.

In case a fault anywhere on the system creates sufficient disturbance to operate any of these sensitive relays, it removes the grid bias from the respective carrier set and puts a carrier current of the correct frequency on the line which functions through receiver relays to open the trip circuit of the breakers at the terminals of the section. Carrier from one terminal of a section will lock out all the breakers of that section in a fraction of a cycle.

The generation of carrier at any terminal is stopped if fault current is flowing into the section at that point as shown by the contacting of directional relays. So long, however, as any one terminal shows fault current outflowing, indicating that the fault is external, the carrier will maintain the lock-out at all terminals and retain the section in service.

In the case of a fault in the section the directional elements at the points where the fault detectors have operated will point toward the section, removing the carrier and allowing the same or other relays to trip the circuit breakers. The relays are all of the high speed type, and the overall relay-operating time for internal faults is of the order of one to two cycles of system frequency.

In case instability or severe swing should occur on the system following the clearance of a fault so that a pilot-protected section is likely to be tripped due to the surge, it is possible to add a device which will indicate such a condition and prevent the trip-out of the line.

This type of pilot protection is the only type of high speed relaying of general application which gives simultaneous high speed clearance at all terminals for a fault anywhere in the protected section and in which provision is available to prevent trip-out of the line section on wide swings between power sources.

It may be applied to any line section of any practicable length without reference to the relaying on the remainder of the system.

The relays are sensitive and where necessary are operative on fault currents below normal load.

The application of these relays can be made effective to a much larger extent than other types on branched or tapped lines, thus allowing greater freedom in the line arrangement and often permitting important economies in line construction and switching. This should not, however, be taken as permitting unrestricted application to all such lines without careful investigation of each case.

### Current Balance Relaying

Where two or more equal parallel circuits without taps exist between common terminal busses, high speed equipment operating on the principle that under fault

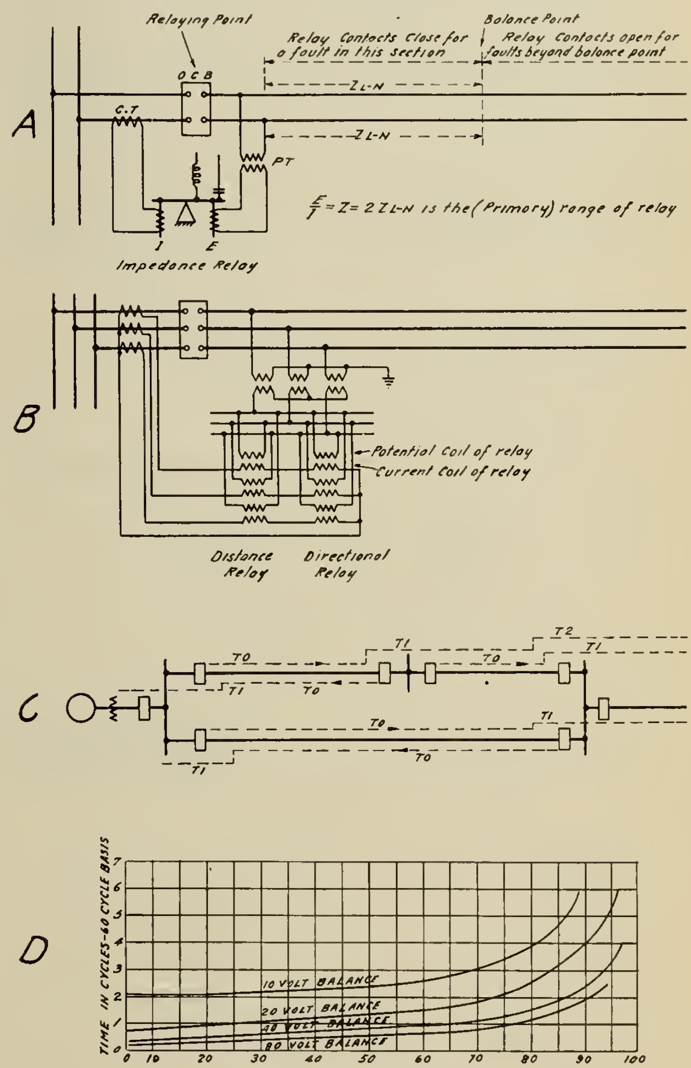


**Fig. 2—Essentials of Distance Relaying for Transmission Circuits.**

conditions their currents will be unbalanced, is available. Such equipment has the advantage of simplicity. Over 60 to 70 per cent in the central section of a line it will give the fastest relay time available, of the order of one one-hundredth of a second. Being inexpensive, it is a useful supplement to other types of protection where it is applicable though the number of possible applications is limited. It is not usually subject to incorrect operation on system surges.

INSTANTANEOUS OVERCURRENT RELAYING

In some systems where the expenditure to install impedance or pilot protective schemes is not considered warranted, or where the induction overcurrent equipment has been installed and is giving reasonably reliable service, but is considered too slow in operation, an important improvement can be made at a nominal cost by adding instantaneous over-current relays. For phase-to-phase these are not of universal application but may often be of assistance if set above the maximum fault current that can pass through a long line section. When used in the residual connection for single-wire or two-wire ground faults on line sections which had dead-grounded transformer neutrals at or near either terminal, they give results in many cases practically equivalent to those obtained from more expensive types.

## SOME DESIGN PROBLEMS IN THE APPLICATION OF HIGH SPEED RELAYING

The successful application of relay equipment which is often so sensitive that it will operate at currents below ordinary load values in one cycle or less of system frequency

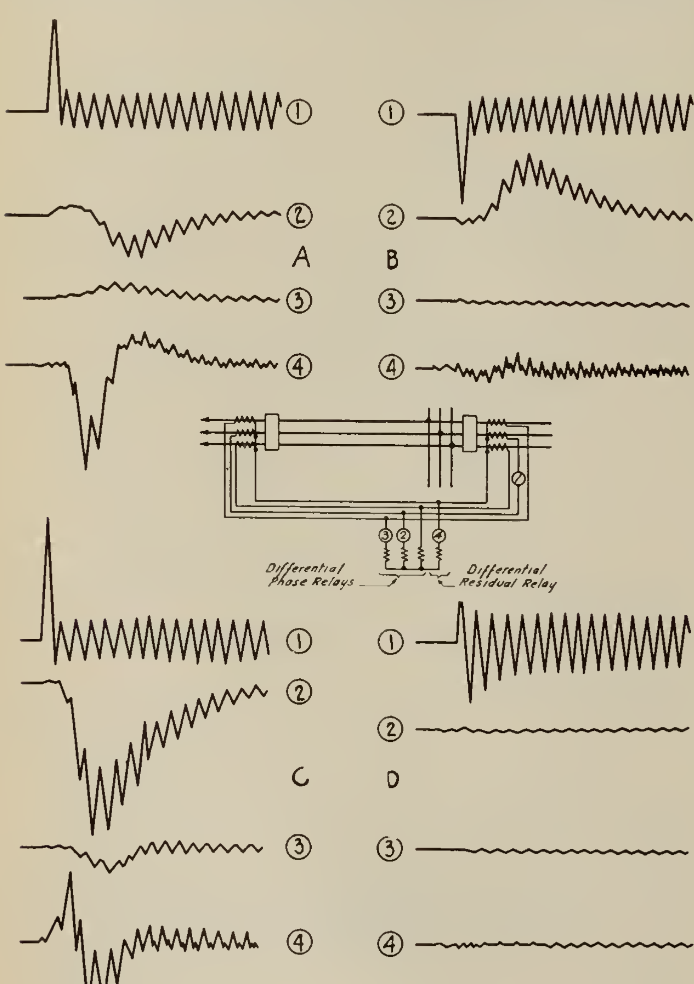


**Fig. 3—Transient Differential Relay Occurrence.**

requires care and judgment in the co-ordination of the relays to the conditions of the system to a greater extent than in the case of slower types of protection. The application for the best results must be based on sound data including the following items:—

1. A fund of information on the nature and manner of occurrence of faults on the power system and of the behaviour of the system and of various types of relaying under fault conditions is essential and may be accumulated in the course of time from the following or other sources:—

By means of automatic recording devices which are instantly put into operation by the disturbance due to the fault and may record the transient conditions of voltage, current, power flow, sequence of circuit clearances and the like. The most useful of these is the automatic oscillograph whose records in the course of time give a very fine insight into the nature of accidental faults on a power system and the consequent behaviour of the system.

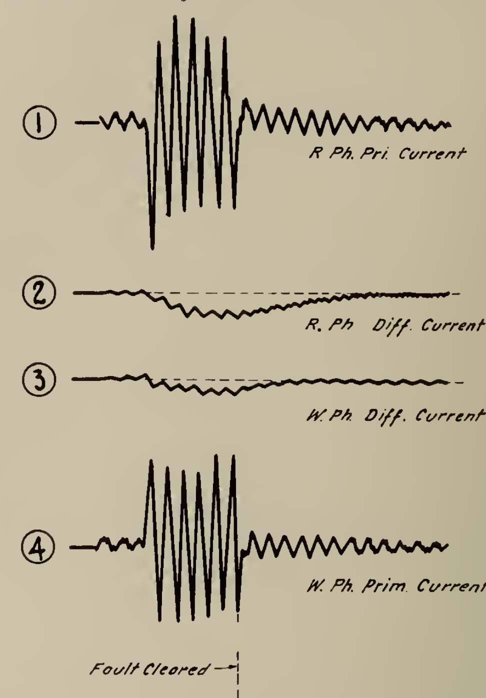


**Fig. 4—Transient Differential Relay Occurrence.**

By means of "staged" tests in which pre-arranged faults are placed on the system in the way to give the maximum of information, allowing observations of system quantities and behaviour to be made and recorded by automatic devices. Such tests should be made after any important relaying installation has been completed, especially if new types are involved, as they will furnish a valuable check on the correctness of the design and adjustments and will often prevent incorrect operation in service.

By means of well designed operation indicators on the relays. High speed relays are usually made of simple elements, each of which performs a single definite function in a sequence. Proper provision of indicators for each function, including timing, will furnish much valuable information.

2. The range of values of fault current and in some cases of voltage and phase angle for each of the relaying points should be available. The most satisfactory way to calculate unbalanced faults is by the method of symmetrical components. For the more complicated networks a calculating board is useful, preferably of the a.c. type; however, solutions from the d.c. board will be sufficiently accurate for most relay applications.

3. Information should be available as to the characteristics and limitations of the relays which it is proposed to use including their speed and the behaviour of the contacts over the range of currents and voltages which may be encountered in service. Freedom from chattering or rebounding of relay contacts is always important in high speed applications and is essential in some lock-out pilot

schemes. The burdens imposed by the relay coils in their relation to current and potential devices on which they are to be used should be known so the overall sensitivity of the equipment can be predicted.

With data of this sort available the power system engineer and the relay designer are prepared to co-operate closely to install equipment which may be expected to give the desired results.

In dealing with sensitive high speed equipment used in differential or other balanced protective schemes where secondary currents from various current transformers are compared and expected to be zero in the relay circuit for faults outside the protected element, there is a certain possibility of improper tripping of the relays on heavy currents "through" the zone.

Figures 3 and 4 have been prepared from oscillograms taken during staged tests on a low voltage and a high voltage system respectively. They indicate that one cause of incorrect relay operation lies in the different response made by current transformers to the transient d.c. component in the primary current wave. In a large number of sensitive equipment and bus zone differential protections which have been under the observation of the author for a number of years, a few incorrect operations of zones at voltages below 15 kv. have been experienced, all for disturbances at that voltage. The author knows of only one case of incorrect operation of a bus differential for a fault on a high voltage line and in that case the fault was a metallic short circuit at the terminals of the station. Presumably the tendency of high voltage faults to strike at the peak of the voltage wave keeps the d.c. component and the transient differential current at a minimum.

In Fig. 3, *A*, *B*, *C*, *D*, are taken from a series of oscillograms of four transitions in the starting sequence of a large synchronous condenser. A number of incorrect differential relay operations had occurred at times of transition from starting to running.

Oscillograph elements 1, 2, 3, 4, are connected in the respective locations shown in the diagram. The following points are of interest:

The exaggerated unidirectional value of the first cycle, element 1, in *A*, *B*, and *C*. This is more severe than would occur on an accidental short-circuit.

The unidirectional nature of the differential current (element 2) for the same phase as 1. The small alternating component is probably due to slight differences in the current transformers.

The irregularity of the differential residual current in element 4.

The very small differential currents in start *D* where the asymmetry of the primary current is not so pronounced.

Figure 4 is from an oscillogram for a metallic short-circuit, wire-to-wire just outside a differentially protected station zone of a high voltage system.

Element 1—current "through" the zone in phase "*R*."

Element 2—current in the differential circuit in phase "*R*."

Element 3—current in the differential circuit in phase "*W*."

Element 4—current "through" the zone in phase "*W*."

It should be noted that the differential current in 2 does not go to zero when the fault is cleared but dies away slowly.

In designing differential schemes which must be sensitive, and at the same time be stable on heavy "through" currents, the following precautions are of assistance:—

The current transformers should be identical in characteristics over a wide range to minimize the unbalanced alternating current. They should be liberal in design with large cores and low resistance in the secondary circulating current path so that the flux and induced voltage will be low under the maximum "through" fault condition.

Tendency to trip on unbalanced a.c. components can sometimes be met by use of the percentage differential principle whereby the relay setting is a percentage of the "through" current and is automatically raised for external faults; this device does not help in case of d.c. differential components as may be seen from Fig. 4. Such components can be bypassed from the relay operating coil by a transient shunt designed to admit the direct current while forcing the alternating component through the operating coil.

For cases where these are not effective as for the irregular transient, one apparent remedy is to use the sensitive relay with slight time delay supplemented by a high speed device set above the transient unbalance.

## BENEFITS FROM THE USE OF HIGH SPEED PROTECTION

The criterion for the value of any relay application is the results obtained in operation. On those power systems where relays of the high speed type have been in service for a number of years the following very definite advantages have been realized:—

Damage to equipment and to structures in stations where the fault has been cleared rapidly has been negligible even with a heavy concentration of current at the point of fault. Oil fires very seldom develop.

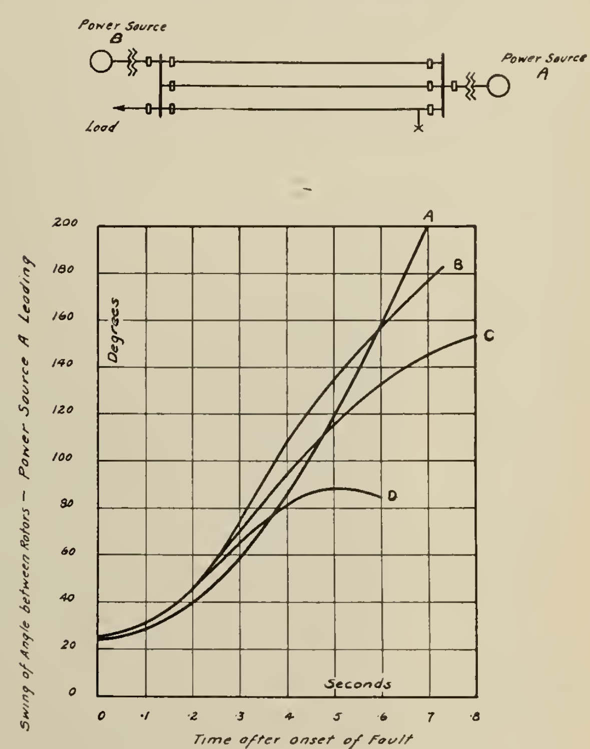


**Fig. 5—Effect of Fault Clearance Time on Transient Stability of a System.**
**Fault Location at X.—Phase to Phase to Phase.**

Burning of the heavier conductors of transmission lines has been greatly reduced so that faults are often difficult to locate. There is seldom any shattering of insulators. So far as arc damage is concerned the circuit is, in a high percentage of cases, in condition to be reclosed immediately.

The operation of interconnected power sources and transmission networks is greatly improved by rapid clearance of faults. Figure 5 is drawn from a study of the effect of fault clearance times on the transient stability of a system.

*A*—Clearance time in 0.3 sec. at end adjacent to the fault; in 0.8 sec. at the remote end.

*B*—Clearance simultaneous in 0.3 sec. as by "carrier" pilot scheme.

*C*—Clearance in 0.2 sec. at the adjacent end and 0.5 sec. at the remote end.

*D*—Clearance simultaneous in 0.2 sec.

System conditions, loads and fault location are approximately constant for all.

It is to be noted that for the particular conditions of test, the system is stable if the fault is completely cleared in 0.2 sec. but not if it lasts for 0.3 sec. The gain for clearance in 0.1 sec. is also apparent.

Comparison of curves *C* and *D* shows the disadvantage in this particular set of conditions of delayed clearance at the end remote from the fault as in the stepped range impedance relaying of *C*. The requirement in this case is for simultaneous clearance at both ends as in *D*.

The increased stability permits heavier loading of interconnections.

When high speed relaying has been applied to systems arranged to take the fullest advantage of it, service outages will be very few no matter how many accidental faults occur. In any case interruptions will usually be short because the circuit can quickly be restored to service.

If faults on a system are cleared rapidly so that voltage dips are short, industrial customers can readily arrange their control equipment to enable their motors to ride through, which will go far to eliminate delays and loss of production in manufacturing operations.

### High Speed Relaying and Automatic Reclosure of Circuits

There is much interest at the present time in automatic reclosure of overhead circuits immediately after a trip-out. With high speed relaying this can be done successfully in as high as 90 per cent of all cases. The equipment to control the reclosure is very simple and inexpensive. With ordinary oil circuit breakers on voltages up to 130 kv. reclosure can be made in one-half to one second after the onset of the fault if the line is completely cleared at high speed.

Standard control equipment is available which will carry induction motors through this period and in the case of synchronous motors will, if it is desirable to do so, remove the field and resynchronize the motor after pulling it into step.

It is of interest to note that while high speed relaying permits automatic reclosure with a high degree of success, the adoption of the latter permits greater freedom and simplicity in the application of high speed relaying by removing to some extent the requirements on the relays for selectivity.

The development of this combination will in the opinion of the author bring forth a major advance both in economy in system construction and in quality of service which can be rendered.

Montreal from Mount Royal.

# Programme for the Semicentennial Meeting

*(All times are Eastern Daylight Saving Time and will be strictly adhered to.)*

MONDAY—JUNE 14th—

Plenary Meeting of Council, and Round Table Conference of Branch Delegates. (Note: these meetings are not open to the general membership.)

TUESDAY—JUNE 15th—

**9.00 a.m.** OPENING OF REGISTRATION, Windsor Hotel, Montreal. (See enclosed attendance form for particulars re advance registration, reservation of rooms, and so forth.)

**10.00 a.m.** OFFICIAL OPENING OF THE SEMICENTENNIAL (Rose Room).
*Chairman*—G. J. DESBARATS, Hon.M.E.I.C., President, The Engineering Institute of Canada.

**Presentation of greetings and reception of official representatives.**

The Institution of Civil Engineers,
The Institution of Mechanical Engineers,
The Institution of Electrical Engineers,
The Royal Aeronautical Society,
Society of Chemical Industry,
The Institution of Engineers and Shipbuilders in Scotland,
The Institution of Structural Engineers,
The Institution of Water Engineers,
The Institute of Marine Engineers,
Institution of Naval Architects,
The Institution of Royal Engineers,
The American Society of Civil Engineers,
The American Society of Mechanical Engineers,
The American Society of Electrical Engineers,
The Society of Naval Architects and Marine Engineers,
Société Française des Electriciens,
Provincial Associations of Professional Engineers,
Canadian Universities and Societies.

**Presentation of Honorary Membership—**

Honorary Membership will be conferred upon the following:

Robert W. Angus, M.E.I.C., Toronto,
G. H. Duggan, M.E.I.C., Montreal,
E. P. Eddy, M.E.I.C., Boston,
Sir Alexander Gibb, M.E.I.C., London, England,
Hon. C. D. Howe, M.E.I.C., Ottawa,
S. J. Hungerford, M.E.I.C., Montreal,
Jacques Rabut, Paris, France,
Hon. Grote Stirling, M.E.I.C., Kelowna.

**Presentation of Prizes—**

SIR JOHN KENNEDY MEDAL—J. G. Sullivan, M.E.I.C., Winnipeg, Man., Past-President of The Institute.

DUGGAN MEDAL AND PRIZE—P. L. Pratley, M.E.I.C., Montreal, Que., "The Superstructure of the Reconstructed Second Narrows Bridge, Vancouver."

GZOWSKI MEDAL —David Boyd, A.M.E.I.C., Lachine, Que., "Modern Arc Welding."

PLUMMER MEDAL —C. R. Whittemore, A.M.E.I.C, Montreal, Que., "The Metallurgy of Metallic Arc Welding of Fine Steel."

LEONARD MEDAL —Mr. L. S. Weldon, Geita, Tanganyika, East Africa, "Mining Methods and Practice at Lake Shore Mine." (Already presented.)

STUDENTS' AND JUNIORS' PRIZES—

JOHN GALBRAITH PRIZE *(Province of Ontario)* —E. C. Hay, Jr.E.I.C., Toronto, Ont., "Selection of Factors of Photo Electric Cells."

PHELPS JOHNSON PRIZE *(Province of Quebec—English)* —Eric G. Adams, Jr.E.I.C., New York (formerly of Montreal), "Trends in Population and Trade Affecting Transportation."

ERNEST MARCEAU PRIZE *(Province of Quebec—French)* —Louis Trudel, S.E.I.C., Montreal, Que., "Etude Comparative sur Modèles Réduits."

**12.45 p.m.** LUNCHEON—(Windsor Hall).
Welcome from His Worship the Mayor of Montreal.
Guest speakers—H. V. Potter, of London, England, representing the Society of Chemical Industry.
J. H. Herron, of Cleveland, Ohio, representing the American Society of Mechanical Engineers.

**2.40 p.m.** "OVERSEAS" SESSION—(Rose Room).
*Chairman*—MAJOR-GENERAL A. G. L. MCNAUGHTON, C.M.G., D.S.O., M.E.I.C.

**The British Grid System** by Johnstone Wright, M.I.E.E., Chief Engineer of the Central Electricity Board, London, England.
This paper will deal with the re-organization of the generation side of the electrical industry in Great Britain subsequent to the piecemeal pre-war development, with the co-ordination of resources through a comprehensive network of interconnecting trunk lines, taking care of the rapidly expanding demand for electricity.

**3.50 p.m.** **Industrial Zoning** by Hugh Beaver, M.I.E.Chem., Partner, Sir Alexander Gibb and Partners, London, England.
This paper will deal with the improvement and cheapening of primary services, such as transport, electricity supply, postal and telephone services, etc., the re-organization of the larger industries, such as shipbuilding, iron and steel, coal, etc., planning new industries and new industrial areas.

**4.50 p.m.** **British Engineering Societies and Their Aims** by Brigadier-General Magnus Mowat, C.B.E., F.R.S.E., Secretary, The Institution of Mechanical Engineers, London, England.
The mediaeval Guilds were the forerunners of engineering institutions, and then came scientific societies of wide scope, such as The Royal Society of London. Amongst the purely engineering bodies, the activities and objects of the Institution of Civil Engineers and The Institution of Mechanical Engineers will be described in some detail, and brief particulars will be furnished of many other national and local associations in the British Isles, the purposes of which are very similar.

**9.00 p.m.** RECEPTION AND SUPPER-DANCE—(Windsor Hall and Rose Room).
Guests will be received by President and Mrs. G. J. Desbarats, and by Past-President and Mrs. F. P. Shearwood.

NOTE:—*Advance Proofs of the majority of the Technical Papers will be available. Copies may be obtained on application to The Secretary, The Engineering Institute of Canada, 2050 Mansfield Street, Montreal.*

**WEDNESDAY—JUNE 16th—**

**9.45 a.m.** Technical Session—(Prince of Wales Salon).

**Symposium on the Burning of Canadian Coals.**

*Chairman*—Dr. R. W. Boyle, m.e.i.c.

B. F. C. Haanel, b.sc., m.e.i.c., and R. E. Gilmore, m.e.i.c., Department of Mines and Resources, Ottawa, will discuss the physical and chemical characteristics of Canadian coals, classifying them according to the new methods adopted by the International Committee on Coal Classification. Investigations relating to boiler heating, carbonization, hydrogenation, and other research work will also be discussed.

F. H. Sexton, ll.d., President, Nova Scotia Technical College, Halifax, N.S. The basic characteristics of Nova Scotia coals.

John Stephens, d.sc., m.e.i.c., Professor of Mechanical Engineering, University of New Brunswick, Fredericton, N.B. Performance at the Grand Lake plant of the New Brunswick Electric Power Commission at Minto, N.B.

R. L. Sutherland, Combustion Engineer, Truax-Traer Coal Company, Winnipeg, Man. The economics of mining and marketing Saskatchewan lignite and its use in domestic and industrial plants.

E. W. Bull, Superintendent, Light and Power Department, City of Regina, Sask. Operating results at the Regina plant with various coals and types of stokers.

Edgar Stansfield, m.sc., m.e.i.c., Chief Chemical Engineer, Research Council of Alberta. The burning of low rank Alberta coal—combustion and control.

C. A. Robb, b.sc., m.e.i.c., Professor of Mechanical Engineering, University of Alberta, Edmonton, Alta. The burning of low rank Alberta coals—the steam generating plant.

R. R. MacNaughton, b.sc., Metallurgist, Consolidated Mining and Smelting Company, of Canada Limited, Trail, B.C. Some phases of the use of British Columbia coal.

J. Roberts, Chief of Motive Power, Canadian National Railways, Montreal. The use of Canadian coals in steam locomotives.

D. G. Munro, Vice-President and General Manager, Montreal Coke and Manufacturing Co. Ltd., Montreal. The use of Canadian coals in the coking and by-product industry.

**9.45 a.m.** Technical Session—(York Room).

*Chairman*—Dr. A. Frigon, m.e.i.c.

A. G. Dickinson, b.sc., Electrical Engineer, Consolidated Mining and Smelting Co., of Canada Limited, Trail, B.C. **Utilization of Electric Power at Trail's Metal and Fertilizer Plant.** The use of electric power plays an important part in the various processes for the production of metal, chemicals and fertilizer. This paper will deal mainly with layout and operation problems.

National Research Council, Ottawa.

J. C. Bernier, b.a.sc., c.e., e.e., Assistant Professor Ecole Polytechnique, Montreal, Que. **Mechanical and Cathode-ray Systems of Television.** An explanation of the principal system of high definition television, discussing their relative merits, with a demonstration of television and electron optics.

E. M. Wood, b.a.sc., Electrical Engineer, Hydro Electric Power Commission of Ontario, Toronto, Ont. **The Characteristics and Application of Modern Relaying.** The importance of protective relay equipment on transmission systems and on various types of stations connected thereto.

A. S. Wall, m.e.i.c., Dominion Bridge Company Limited, Montreal, Que. **Modern Technique in Welding Processes.**

**12.45 p.m.** Luncheon—(Windsor Hall).

Welcome from the Prime Minister of the Province of Quebec.

Guest speakers—A. C. Gardner, Glasgow, Scotland, representing the Institution of Engineers and Shipbuilders in Scotland.
Harrison P. Eddy, m.e.i.c., Boston, Mass., Past-President, The American Society of Civil Engineers.

**2.40 p.m.** Technical Session—(Prince of Wales Salon).

*Chairman*—H. F. McKiel, m.e.i.c.

R. E. Chadwick, b.sc., m.e.i.c., President, The Foundation Co. of Canada Limited, Montreal, Que. **Precast Concrete Units in Engineering Construction**, especially developing the idea that such units can be built better and more economically at a suitable construction yard rather than *in situ*.

C. J. Mackenzie, b.e., m.e.i.c., Dean of Engineering, University of Saskatchewan, and

B. A. Evans, m.sc., Senior Assistant Engineer, Department of Public Works of Canada, Ceepee, Sask. **The Ceepee Bridge**, covering the design and construction of a highway bridge across the North Saskatchewan River at Ceepee, Sask., which consists of approach girders and three bow-string arches of long span, involving unusual design features. Results of extensometer tests. Construction methods in low temperatures.

J. B. D'Aeth, b.sc., m.e.i.c., Engineer, Fraser Brace & Company Limited, Montreal, Que. **Freight Hauling in Undeveloped Territories**, especially as related to the construction, mining and forestry industries in Canada. Methods and cost of transporting heavy machinery, equipment and supplies to remote places.

**2.40 p.m.** Technical Session—(York Room).

*Chairman*—Brigadier J. Lindsay Gordon, d.f.c., a.m.e.i.c.

H. J. McLean, m.e.i.c., Production Superintendent, Calgary Power Company Limited, and

O. H. Hoover, b.a.sc., m.e.i.c., Engineer-in-Charge, Dominion Water Power and Hydrometric Bureau, Calgary, Alta. **A Study of Standard and Increment Methods of Measuring Stream Flow**, describing methods used for the efficient apportionment of load to machines in each hydro-electric plant of a system, and the hourly calculation of water available.

J. H. Parkin, m.e., m.e.i.c., f.r.ae.s., National Research Council, Ottawa, Ont. **North Atlantic Air Service London-Montreal.** Different factors involved in the establishment of an intercontinental air service by heavier-than-air aircraft across the North Atlantic—such as nature of service, barriers and methods of surmounting them, possible routes, organization of route and types of aircraft.

H. B. Bowen, m.e.i.c., Chief of Motive Power, Canadian Pacific Railway, Montreal, Que. **Modern Motive Power.**

**7.30 p.m.** Banquet—(Rose Room).

Guest of Honour and Principal Speaker—His Excellency the Governor General, Lord Tweedsmuir.

Other Speakers—Sir Alexander Gibb, London, President, The Institution of Civil Engineers; L. C. Hill, Los Angeles, President, The American Society of Civil Engineers; Arthur Surveyer, Past President, The Engineering Institute of Canada; E. A. Cleveland, Past President, The Engineering Institute of Canada.

This function will be broadcast between the hours of 9 and 9.30 p.m., Eastern daylight saving time (which will include the address of His Excellency the Governor General), over the national network of the Canadian Broadcasting Corporation, comprising the following stations—

CJCB—Sydney; CHNS—Halifax; CFCY—Charlottetown; CKCW—Moncton; CFNB—Fredericton; CHSJ—Saint John; CHNC—New Carlisle; CRCS—Chicoutimi; CRCK—Quebec; CRCM—Montreal; CRCO—Ottawa; CRCT—Toronto; CRCW—Windsor; CKSO—Sudbury; CKPR—Fort William; CKY—Winnipeg; CKCK—Regina; CFQC—Saskatoon; CFAC—Calgary; CJCA—Edmonton; CJOC—Lethbridge; CRCV—Vancouver.

It is probable that other stations will be added to the network in due course.

THURSDAY—JUNE 17th—

VISITS TO PLACES OF INTEREST

*(Subject to Revision)*

Tour 1—Leave Windsor Hotel 8.45 a.m., board "Sir Hugh Allan" at foot of McGill Street 9 a.m., general tour of the Harbour; debark Imperial Oil Company's wharf 12 noon. Lunch, courtesy Imperial Oil Company, inspection Imperial Oil Company's refinery at Montreal East, return by bus to Montreal at 4 p.m.

Tour 2—Leave Windsor Hotel 9.10 a.m. for Shell Oil Company's Montreal East Refinery and Canadian Vickers Limited; lunch at the latter plant. Return to Montreal 3.45 p.m.

Tour 3—Leave Windsor Hotel 9.15 a.m. for Montreal East, Canadian Copper Refineries, Canada Wire and Cable Company, Canadian Steel Foundries, return to Montreal 1.30 p.m.

Tour 4—Leave Windsor Hotel 9.20 a.m. for Canadian Pacific Angus Shops, Montreal Locomotive Works, Canadian National Shops, Point St. Charles, lunch, courtesy Montreal Locomotive Works.

Tour 5—Leave Windsor Hotel 9.25 a.m., bus to Cartierville and Pont Viau, thence to Pie IX Blvd. bridge (under construction), across Jacques Cartier bridge to South Shore, thence to Caughnawaga bridge and to plant of Dominion Bridge Company, who will provide lunch. Inspection of Bridge Company's plant and return to Montreal 4 p.m. This tour will include 4 steel bridges and 1 concrete bridge.

Tour 6—Leave Windsor Hotel 9.30 a.m. for Beauharnois, inspection of Beauharnois Hydro-Electric plant and works, lunch at plant, return to Montreal 4 p.m.

Tour 7—Leave Windsor Hotel, 9.35 a.m. for Canadian Car and Foundry Company, Turcot and Dominion plants; Dominion Engineering Works Limited at Rockfield, who will provide a buffet lunch, return to Montreal 4 p.m.

Tour 8—Leave Windsor Hotel 9.40 a.m. for Steel Co. of Canada, Notre Dame and St. Henry plants, and Canadian Tube and Steel Products Company at Ville Emard, return to city at 3.45 p.m.

Tour 9—Leave Windsor Hotel at 9.45 a.m. for Northern Electric Company's works; thence to Bell Telephone Company's toll building, who will provide a buffet lunch. Then to Canadian Marconi Company's works in the Town of Mount Royal, return to Montreal at 3.45 p.m.

Tour 10—Leave Windsor Hotel 9.50 a.m. for the plants of the Dominion Textile Co. Limited, and Belding Corticelli Company.

Tour 11—Leave Windsor Hotel at 10 a.m. for the Montreal Water Board pumping station, filtration plant and McTavish upper level pumping station, returning at 12.45 p.m.

Golf—For those who wish to play Golf, arrangements can be made at one or more of the clubs in the vicinity of Montreal.

**4.00 p.m.** GARDEN PARTY—(McGill University Campus).
Through the courtesy of McGill University, arrangements have been made to hold a Garden Party on the Campus. With the kind permission of the Commanding Officer, Colonel A. T. Howard, V.D., the band of The Black Watch (Royal Highland Regiment) of Canada will be in attendance.

**8.00 p.m.** SMOKING CONCERT—(Windsor Hall).

FRIDAY—JUNE 18th—OTTAWA—

**8.50 a.m.** Leave Windsor Street Station, Canadian Pacific Railway, 8.50 a.m. (7.50 a.m. Eastern Standard Time), arrive Ottawa 12 noon (11.00 a.m. Eastern Standard Time).
(Members returning to the West of Ottawa on convention tickets will be able to stop over on their return ticket. Others will travel on a group rate, which will depend on number of tickets.)

**12.45 p.m.** LUNCHEON—(Chateau Laurier, Ottawa).
Welcome by His Worship the Mayor.
Guest Speaker—To be announced.

VISITS TO PLACES OF INTEREST

Tour 1—Leave Chateau Laurier 2.30 p.m. for inspection of Chelsea and Farmers Power plants of the Gatineau Power Company on the Gatineau river, return to Ottawa 6 p.m.

Tour 2—Leave Chateau Laurier 2.35 p.m. for inspection of Gatineau mill of Canadian International Paper Company at East Templeton, return to Ottawa 5.30 p.m.

Tour 3—Leave Chateau Laurier 2.40 p.m. for inspection of laboratories of the National Research Council.

Tour 4—Leave Chateau Laurier 2.45 p.m. for "circular tour" taking in the Central Experimental Farm, Parliament Buildings, Memorial Chamber, Peace Tower, and the Driveway, return 5.30 p.m.

**7.30 p.m.** DINNER—(Chateau Laurier, Ottawa).
Guest Speaker—(to be announced).

**9.30 p.m.** DANCE—(Chateau Laurier, Ottawa).

C.N.R. Locomotive 6400 Series.

SATURDAY—JUNE 19th—

The heads of a number of Government engineering departments will be "at home" to receive visitors. Announcement will be made later as to the details.

## Ladies Programme

With the exception of the Smoking Concert on Thursday evening, ladies will be welcome at all the social functions and at the technical sessions if they so desire. The following additional arrangements have been made for the ladies.

TUESDAY, JUNE 15th—
**4.00 p.m.** TEA—(Prince of Wales Salon, Windsor Hotel).

WEDNESDAY, JUNE 16th—
**3.00 p.m.** LAKESHORE DRIVE AND TEA—(Royal St. Lawrence Yacht Club, Dorval).

THURSDAY, JUNE 17th—
**8.00 p.m.** BRIDGE—(Prince of Wales Salon, Windsor Hotel).

## TRAVEL ARRANGEMENTS

Through the courtesy of the Canadian Passenger Association all members of The Institute together with their dependents may obtain special fare concession for round trip equivalent to 1⅓ times single fare plus 25 cents, on presentation of the identification certificate enclosed herewith. Alternatively one-way tickets may be purchased at ⅔ single fare in either direction.

Tickets will be issued on the following dates (inclusive in each case):—British Columbia—June 8 to 14; Alberta—June 9 to 15; Saskatchewan, Manitoba and Ontario, Port Arthur and West—June 10 to 16; Ontario, East of Port Arthur, Quebec and Maritime Provinces—June 11 to 17.

### DO NOT MISLAY IDENTIFICATION CERTIFICATE

**For full information regarding travel arrangements, issuing of tickets, parties travelling together—members should get in touch with their local Branch representative as under— (or local Railway Agent)**

**Halifax—**
R. R. Murray, A.M.E.I.C.,
c/o Wm. Stairs, Son & Morrow Ltd.,
Halifax, N.S.

**Cape Breton—**
S. C. Mifflen, M.E.I.C.,
60 Whitney Avenue,
Sydney, N.S.

**Saint John—**
J. R. Freeman, M.E.I.C.,
58 Orange Street,
Saint John, N.B.
Phones—Office, 3-2327;
Home, 3-7939.

**Moncton—**
V. C. Blackett, A.M.E.I.C.,
c/o Engineering Dept., C.N.R.,
Moncton, N.B.

**Saguenay—**
G. H. Kirby, A.M.E.I.C.,
P.O. Box 22, Riverbend, Que.

**Quebec—**
Jules Joyal, M.E.I.C.,
Quebec Public Service Commission,
Court House,
Quebec, Que.

**St. Maurice Valley—**
C. H. Champion, A.M.E.I.C.,
73 Bonaventure Street,
Three Rivers, Que.

**Ottawa—**
W. H. Munro, M.E.I.C.,
Office—Ottawa Electric Co.,
56 Sparks St., Ottawa,
Phone Queen 5000;
Home—Apt. 40, 300 Cooper St.,
Ottawa, Queen 3391.

**Peterborough—**
W. T. Fanjoy, A.M.E.I.C.,
627 Homewood Ave.,
Peterborough, Ont.
Phones—575 J;
Office, 2200 local 27.

**Kingston—**
R. F. Legget, A.M.E.I.C.,
109 Wellington Street,
Kingston, Ont.
Phone 3992.

**Toronto—**
W. E. Bonn, M.E.I.C.,
Canadian Dredging Company,
Harbour Commission Bldg.,
Toronto, Ont.
Phones—Elgin 2005:
Home, Mohawk 2927.

**Hamilton—**
W. J. W. Reid, A.M.E.I.C.,
Otis-Fensom Elevator Company,
Hamilton, Ont.
Phones—Regent 3850;
Home, Baker 0988.

**London—**
A. O. Wolff, M.E.I.C.,
504 Baker Street,
London, Ont.

**Niagara Peninsula—**
P. A. Dewey, A.M.E.I.C.,
1224 Ontario Avenue,
Niagara Falls, Ont.

**Border Cities—**
Fred Stevens, A.M.E.I.C.,
690 Windermere Road,
Windsor, Ont.
Phones—Office, 3-7452;
Home, Windsor 4-1687.

**Sault Ste. Marie—**
N. C. Cowie, Jr.E.I.C.,
15 Hearst Street,
Sault Ste. Marie, Ont.
Phone 553 J.

**Lakehead—**
G. R. McLennan, A.M.E.I.C.,
80 North High Street,
Port Arthur, Ont.

**Winnipeg—**
H. L. Briggs, A.M.E.I.C.,
Winnipeg Hydro-Electric System,
55 Princess St.,
Winnipeg, Man.
Phones—Office, 84810;
Home, 39367.

**Saskatchewan—**
J. J. White, M.E.I.C.,
City Hall, Regina, Sask.
Phone—22419.

**Lethbridge—**
E. A. Lawrence, S.E.I.C.,
207-7th Street S.,
Lethbridge, Alta.
Phone—2136.

**Edmonton—**
M. L. Gale, A.M.E.I.C.,
9914-111th Street,
Edmonton, Alta.
Phone—23754.

**Calgary—**
James McMillan, A.M.E.I.C.,
506 Insurance Exchange Bldg.,
Calgary, Alta.

**Vancouver—**
Theo. V. Berry, A.M.E.I.C.,
Vancouver and Districts Joint Sewerage and Drainage Board,
1303 Bekins Bldg.,
Vancouver, B.C.
Phone—Seymour 6223.

**Victoria—**
Kenneth Reid, Jr.E.I.C.,
1336 Carnsew Street,
Victoria, B.C.
Phone—Empire 5505.

### HOTEL ACCOMMODATION

Reservations of rooms will be made by the Committee at both the Windsor Hotel, Montreal, and the Chateau Laurier, Ottawa. (See Advance Registration Form for detail of rates.) As the Registration will be unusually heavy it will be appreciated if you will return the Advance Registration Form as early as possible.

A cordial welcome is assured all visiting members. Guests will also be welcome at the various functions upon introduction by a member.

### Prices of Tickets

**MONTREAL**

| | | |
|---|---|---|
| Tuesday, June 15th, | Luncheon | $1.50 |
| | Complimentary to visiting ladies. | |
| | Ladies Tea | $0.50 |
| | Complimentary to visiting ladies. | |
| | Supper Dance, Couple | $5.00 |
| | Single | $3.00 |
| Wednesday, June 16th, | Luncheon | $1.50 |
| | Lakeshore Drive, Ladies only | $1.00 |
| | Banquet | $3.00 |
| Thursday, June 17th, | Garden Party | $1.00 |
| | Complimentary to visitors. | |
| | Smoking Concert | $1.25 |
| | Ladies Bridge | $0.50 |

**OTTAWA**

| | | |
|---|---|---|
| Friday, June 18th, | Luncheon | $1.00 |
| | Dinner and Dance | $2.50 |
| | Dance only | $1.25 |

It will be appreciated if members would care to send in their cheque for tickets with their advance registration form, in which event tickets and badge will be prepared in advance and found at the "Advance Registration Desk." Adjustments can be made after arrival for tickets not required, or additional tickets obtained.

### COMMITTEES

**Ladies Committee—**
Mrs. F. P. Shearwood,
Convenor.

**Ottawa Committee—**
Allan K. Hay, A.M.E.I.C.,
Chairman.

**Reception Committee—**
F. S. B. Heward, A.M.E.I.C.,
Chairman.

**Semicentennial Committee—**
J. L. Busfield, M.E.I.C.,
Chairman.

## DESCRIPTION OF PLACES TO BE VISITED

MONTREAL AND VICINITY—JUNE 17TH—

**The Harbour of Montreal,** situated at the junction of ocean and inland navigation on the River St. Lawrence, approximately 1,000 miles from the sea—an outstanding example of modern seaport organization and recognized as one of the great harbours of the world. (*Tour 1*)

**The Beauharnois Power Development,** a modern hydro-electric plant with an installed capacity of 450,000 hp. (nine turbine units), 15 miles of canal, and control dams on the River St. Lawrence. (*Tour 6*)

**Dominion Engineering Works, Limited,** manufacturers of heavy commercial machinery in Canada, containing the largest vertical boring mill in the Dominion. It is possible that a large modern paper machine will be assembled and available for inspection. Special gear cutting machines will also be set up for demonstration. (*Tour 7*)

**Montreal Water Board,** the largest single municipal pumping station in the world, supplying the whole of the City of Montreal; together with a modern filtration plant with continuously automatic chlorinator regulated by photo-electric cell contact, designed by the Board's own engineering staff. (*Tour 11*)

**Dominion Bridge Co. Limited.** Fabricators and erectors of all types of structural steel work, boilers, coal pulverizers, cranes, etc. This Company has built many of the most important bridges in Canada. They are pioneers in welded construction, and their shop is equipped with the largest stress relieving furnace in Canada, X-ray apparatus and other modern equipment.

During the visit the fabrication of both welded and riveted steel work, pressure vessels, and heavy machinery will be in progress, including the construction of the Pie IX Boulevard Bridge.

In the course of Tour 5, the following bridges will be visited:—

Pont Viau is a five-span, three-hinge, arch bridge of reinforced concrete and provides for six lines of traffic. It is 1,050 ft. in length, the spans, varying from 202 to 222 ft. in length, are 56 ft. in width.

The Jacques Cartier Bridge is approximately 9,150 ft in length, with the main span a symmetrical cantilever, providing a clear navigation channel of over 1,000 ft. and a clearance of 155 ft. The north and south approaches to the central span consists of a series of short deck truss spans carried on masonry, concrete and steel piers. The central roadway is 36 ft. wide.

The Honoré Mercier Bridge is approximately 4,470 ft. in length, with a steel superstructure 2,918 ft. consisting of thirteen spans; ten of these being 235 ft. and the main span 400 ft. In all there is a clearance of 120 ft.

Cartierville Bridge is a modern three-span steel highway bridge.

The Pie IX Boulevard Bridge, which is now under construction, will comprise five-span arches supporting a composite superstructure.

**Canadian Car and Foundry Company, Limited,** with freight and passenger cars in all stages of construction from the wheel foundry and the spring shop, through the fabricating shop to the delivery track. (*Tour 7*)

**Canadian Steel Foundries, Limited,** a completely equipped modern plant for the manufacture of steel castings. (*Tour 3*)

**Canadian National Railways** Locomotive Shops, Montreal, one of the most modern locomotive shops on the continent—its power plant, machine shop and assembly tracks are under one roof. The Railway will make arrangements for a new streamlined locomotive to be at the shop for detailed inspection. (*Tour 4*)

**Belding-Corticelli Limited**—A modern plant for manufacturing silk goods from the raw product to the finished article, such as silk hosiery and ribbons. The processes involve taking the raw silk and manufacturing it into the necessary threads which are then put through various processes plus the dyeing, pairing and boxing. In the Ribbon Mill both silk and rayon ribbons are woven and dyed. (*Tour 10*)

**Shell Oil Co. of Canada Limited**—The Montreal East Refinery consists of a modern combination topping, cracking and stabilizing system producing gasoline and fuel oil direct from crude oil. A vapour phase clay treating system is built integral with the cracking plant, and an absorption system is employed to strip process gas. Steam required for refinery operations is generated in the company's boiler plant, and there is a well equipped laboratory for making standard petroleum tests. (*Tour 2*)

**Imperial Oil Limited**—The Montreal Refinery at Montreal East has a capacity of 20,000 barrels daily, with a full range of over one hundred products, gasoline, lubricants, kerosene, distillates and asphalts (the largest asphalt refinery in Canada). Gasoline is produced by the tube and tank cracking process, and of special interest is the combined atmospheric vacuum and cracking unit. (*Tour 1*)

**Canadian Copper Refiners Limited**—The Montreal East plant is a modern refinery which refines blister by the electrolytic process, and produces refined copper shapes, gold and silver bullion, also refined selenium and tellurium. The plant has a capacity of 7,500 tons of copper per annum. (*Tour 3*)

**Canadian Tube and Steel Products Limited**—Manufacturers of bolts, nuts and rivets of all descriptions, wire and wire products, wire nails, screws, the rolling of merchant bars, structural shapes, angles, etc. The plant also includes a pipe mill for the manufacture of various forms of pipe, and electric furnace for the melting of steel. (*Tour 8*)

**Montreal Locomotive Works Limited**—This plant covers sixty acres and consists of foundry, forge, boiler, wheel, cylinder, tank, machine, and erecting shops. Thirty Hudson type locomotives are under construction for the Canadian Pacific Railway Company. (*Tour 4*)

**Northern Electric Co. Limited**—At this plant everything in the nature of manual and automatic telephone apparatus and equipment is manufactured, together with a complete line of telephone wires and cables, in addition to which rubber covered wire and paper insulated lead covered power cables are made to meet all commercial low and high tension requirements. Here, too, are manufactured special products such as broadcasting transmitters, radio receiver sets, fire alarm and police signal equipment, theatre and speech input equipment. (*Tour 9*)

**Bell Telephone Company**—Long distance building housing switchboards, test desks, power apparatus, repeater units, etc., taking care of all long distance traffic. Also equipment for overseas messages between Canada and the world in general. This plant also contains apparatus through which radio programmes from the United States for distribution to Eastern Canadian radio stations are handled. An opportunity will also be provided for a visit to the Historic Museum in the head office building. (*Tour 9*)

**Steel Co. of Canada Limited**—At Notre Dame Works there are 9, 12 and 18 in. merchant mills, rolling bars for concrete reinforcing, etc., and also bars to be further processed in the horse shoe and bolt works. There is also a wire mill, which draws wire for the trade, for the bolt works and for the wire nail department. All kinds of wire nails are manufactured, including cut nails, staples, tacks, etc. The bolt and nut works manufactures bolts and nuts, washers, pole line hardware, rivets, spikes, etc.

At St. Henry Works, located about one mile west of Notre Dame Works. buttweld pipe is manufactured up to and including 4 in. diameter, also couplings, nipples and gate valves. (*Tour 8*)

**Canadian Pacific Railway Company,** Angus Shops, situated in the north end of the City. These are the largest locomotive shops on the Continent where all heavy maintenance and overhaul work is carried out. The shops also include passenger coach and freight car departments, iron foundries, paint shops, and at the present time there is considerable work being done in the installation of air conditioning equipment in passenger coaches. (*Tour 4*)

**Canada Wire and Cable Co. Limited,** Montreal East Plant, adjacent to Canadian Copper Refineries. At this plant copper wire bar is received from the Copper Refineries and put through various rolling and annealing processes to produce rods and wire. The bars are first heated in oil fired billet heating furnaces, then delivered to a roughing mill, and finally passed through intermediate and finishing mills to the pickling room. (*Tour 3*)

**Canadian Vickers Limited**—The following activities of interest will be available for inspection:—Industrial Department: mining machinery, Ontario Paper penstock, boilers and possibly hydraulic turbines; Structural Steel Department: steel for Beattie Mines building and roaster; Marine Department: besides drydock activities, shipyard will be completing a barking drum barge; Aircraft Department: all-metal planes at various stages of construction. (*Tour 2*)

OTTAWA AND VICINITY—JUNE 18TH—

**Canadian International Paper Company**—Gatineau Newsprint Mill, at East Templeton, on the Ottawa river, about 5 miles from the City of Ottawa, has a capacity of 750 tons of paper per day, and covers an area of over 10 acres, while the entire mill site covers 27 acres. The mill is of modern design, electrically operated throughout, with power from Farmers, Chelsea and Paugan plants of the Gatineau Power Company.

**Gatineau Power Company**—Plants at Chelsea and Farmers on the Gatineau river are about 8 miles from Ottawa. These two plants form part of a comprehensive development of 100 miles of river, which has a minimum regulated flow of about 10,000 c.f.s. Chelsea and Farmers operate under heads of 97 and 67 ft. respectively. The former is equipped with 34,000 and the latter four 24,000 hp. units.

**National Research Council, Ottawa**—A modern building situated on the bank of the Ottawa river houses administrative offices, and biological, chemical, physical and electrical engineering laboratories. In the Annex are the mechanical and aeronautical engineering laboratories having a 9-ft. wind tunnel, and a water channel 400 ft. long, laboratories for engine and fire hazard testing, and extensive model and instrument shops.

**Central Experimental Farm**—Comprising over 800 acres, is the headquarters of the Dominion system of experimental farms and stations, and is operated under such divisions as Animal Husbandry, Agricultural Bacteriology, Bees, Botany, Plant Pathology, Cereals, Chemistry, Economic Fibre Production, Field Husbandry, Forage Crops, Horticulture, Illustration Stations, Poultry and Tobacco. Beautiful, well kept grounds is the keynote of the farm, and points of special interest include the Arboretum, The Flower Garden, The Macoun Memorial Garden, Greenhouses, Live Stock, Farm Buildings and Machinery, Experimental Fields and Plots.

**The Ottawa Driveway**—The City of Ottawa is almost entirely circled by a beautiful driveway following the Rideau canal, Dow's lake, and the Ottawa river. On the Driveway are located many of Ottawa's finest homes.

**The Parliament Buildings**—Are the centre of governmental interest and are well worth a visit. The Peace Tower and Memorial Chamber are striking centres of public interest, especially when the carillon is in operation.

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OF CANADA



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## Electricity Supply in Great Britain

The effective co-ordination of the policies of a number of independent local authorities is always difficult and sometimes almost impossible. The existence of vested interests, the divergent views of various advisers, insistence on local view points, and the wet blanket of the pessimists oft n combine to hinder progress. The conditions under which the electrical supply industry developed in Great Britain in the eighties and nineties resulted in a state of affairs which was far from ideal, which seriously delayed the general adoption of electrical equipment, and even hampered the country's industrial efforts during the war. It is to be noted that in Britain there are few sites at which any substantial amount of water power can be developed, but coal is abundant and cheap, so that electrical energy was generated by coal-fired, steam-driven stations. In general, manufacturing establishments were served by their own individual steam plants, with a resulting inflexibility which made rapid industrial expansion very difficult.

Under these circumstances, there sprang up a multitude of small separate electricity-distributing authorities, mainly supplying the towns, paying little attention to the rural areas, and served by a correspondingly large number of small generating stations. There was an extraordinary multiplicity of voltages, frequencies, and systems of distribution. There could be little or no standardization of equipment, the capital expenditure was excessive due to the high proportion of reserve plant which had to be provided, and the fuel consumption was great owing to the small average scale of production.

During the reconstruction period after the war, it became increasingly evident that British industry was being handicapped by the lack of cheap and widely distributed electrical power, while practically nothing had been done towards popularizing the use of electricity in country districts. Attempts at voluntary reorganization of the industry were not successful and would, at best, have perpetuated local differences leading to the continuation of the existing anomalous arrangements. As a result Parliament took action in 1926 by the creation of a Central Electricity Board, with powers to construct and operate a national network of high voltage transmission lines, to control the generating stations connected with it, to standardise frequency, and to supply electricity in bulk to the various local distributing authorities. The Board members are chosen as representative of a number of the principal business and community interests of the country; no member of Parliament is eligible. It is not a government department and is free from political control. The capital required has been raised by the public issue of long term, fixed interest stock, and beyond earning this interest, the Board is not allowed to make any profits. The general type of organization of which the Central Electricity Board is thus an example is one which has proved successful in England in another branch of public utility service, namely, the co-ordination and control of passenger transport in London.

Serving a population of more than forty millions in a highly industrialized country, the Central Electricity Board's operations are on a large scale. The capital expenditure on the 'Grid,' its main network of high voltage lines, is nearly one hundred and fifty million dollars. This network provides for the interconnection of over one hundred and fifty generating stations so as to reduce reserve plant in individual stations to a minimum. It enables the best plants to be run continuously; the less efficient to be restricted in operation, and the inefficient closed down. With these ends in view, the Board directs the operation of the various stations connected with the Grid, and purchases their entire output at the actual cost of production. It then supplies the various local distributing authorities at its standard tariff rates.

In a paper published in this issue of the Journal, the Board's chief engineer describes its operations. He is able to point out that although now only in its tenth year of operation, the Bc ard's activities have already had a marked effect on costs. They have assisted rural development; helped industrial decentralization and railway electrification; have promoted the use of electricity in the home and in fact have made the country electricity-minded. These results must be a matter of justifiable pride to all who have been connected with the development of the scheme, and have taken part in putting it into effect.

In their work the Board's technical officers have taken full advantage of the latest developments in transmission, switching, and protective apparatus, and have completed a modern and effective installation. On the financial side, the cost of installing the system was substantially less than the original Estimate, and as regards results, the total fuel consumption of the stations connected to the Grid is nearly two million tons less than it would have been had the formerly existing system, (or lack of system) continued, the corresponding annual monetary saving being some eight million dollars.

The Grid is thus an example of a great public utility established under government initiative, but effectively divorced from politics; paying reasonable return on the capital invested; operated in the interest of the country as a whole, and interfering as little as possible with the business of the local authorities, railways or industrial concerns which it supplies. We have not many organizations in Canada to which all of these statements would apply.

Hail to the crown by freedom shaped---to gird
An English sovereign's brow! and to the throne
Whereon he sits! whose deep foundations lie
In veneration and the people's love.

## The Ballot on the Consolidation Proposals

The interest taken by the Corporate membership of the Institute in the question of "Consolidation" is shown by the heavy vote which was cast, practically fifty per cent of the membership having sent in their ballots, a proportion of votes to voters which is unusually high. The results of this ballot, which are announced on this page, indicate clearly that the proposals of the Committee on Consolidation have not been approved by the Corporate membership but do not mean that the majority of The Institute members are opposed to Consolidation as a live policy of The Institute. On the contrary, there is abundant evidence that a large body of the Corporate membership believe that joint action with the Professional associations, leading to the ultimate formation of a national body, is highly desirable. While the present vote shows that the particular scheme put forward by the Committee on Consolidation is not acceptable to our corporate membership, it must not be taken as ruling out further action nor the exploration of other possibilities.

The negative decision thus reached, after two years of effort by the Committee on Consolidation, will come as a disappointment to those who anticipated rapid and comparatively easy progress towards the desired end, but will meet the views of the presumably larger number, who hold that a different line of advance should have been adopted. Actually, there are many features of the Committee's proposals which may well be considered in any discussions into which the Council may enter, either with the Dominion Council, if that body decides to confer with the Council of The Institute, or with those Professional associations which have signified their desire for co-operation with The Institute.

At this point it seems proper to recall the views expressed by speakers at the Seventh Plenary Meeting of Council, who clearly indicated the wish of the engineers in Manitoba for prompt action. The hope was expressed that this would be along the lines of a proposal from a joint committee of the Winnipeg Branch of The Institute and the Association of Professional Engineers of Manitoba, which had been submitted to The Institute Council in November 1934. This proposal was then approved by Council, subject to further consideration, but its presentation took place just before the formation of the Committee on Consolidation by the Annual General Meeting, in February 1935, and action upon it has remained in suspense since that time.

Following suggestions made at the Plenary Meeting of Council, some of the features of the Manitoba scheme were later included in the proposals of the Committee on Consolidation. Similar joint committees have also functioned in Saskatchewan and Alberta, although their projects did not reach such a definite stage of development as in Manitoba.

There has also been a movement in the Maritime Provinces. During the fall of 1934 a scheme of local co-operation was drafted for Nova Scotia in sufficient detail to be submitted to The Institute branches there, and to the Nova Scotia Professional Association, with some prospect of eventual agreement. In this case also activity had to be suspended while the Committee on Consolidation was developing its proposals.

When the result of the ballot was reported to Council on April 30th last, attention was naturally drawn to the desirability of ascertaining and, if possible, meeting the present views of the provinces named above. It was suggested that as a preliminary step it might be possible for members of Council to visit the Maritime or Prairie Provinces and confer informally with engineers there. As a result of such conferences it was hoped that at the Plenary Meeting of Council, which is to be held on June 14th, an idea could be formed of the views now held in those provinces, particularly as to the possibility of using the existing provisions in The Institute by-laws for the formation of Provincial Divisions as a basis for co-operation with the several Professional Associations.

It is encouraging to be able to announce that as a result of that discussion in Council President Desbarats has kindly undertaken to journey to Winnipeg within the next two or three weeks, while Mr. Busfield has been good enough to arrange for a visit to Halifax and Saint John. In these cities The Institute councillors are being asked to arrange for informal round table conferences with the officers of the Professional Associations in the hope that a clear mutual understanding may result.

Thus it will be evident that the result of the recent ballot does not close the "consolidation" chapter in the Institute's history, but clarifies the situation, and, it is hoped, opens the way for the development of a more acceptable programme for joint action between The Institute and the Professional Associations.

## Ballot on Amendments to By-laws 1937

The report of the scrutineers appointed by Council to canvass this ballot, was submitted and accepted at the Council meeting on April 30th.

The scrutineers certify the following results:—

*Vote I.* (Proposals submitted by the Committee on Consolidation, less subsection 7(*b*))
In favour .......... 677
Against .......... 780
Total valid ballots cast .......... 1,457
Affirmative votes required under Section 75 of the By-laws (2/3 of 1,457), 972.
This item therefore *fails* of adoption, lacking 295 affirmative votes.

*Vote II.* (Council's proposed version of Subsection 7(*b*))
In favour .......... 398
Against .......... 866
Total valid ballots cast .......... 1,264
Affirmative votes required (2/3 of 1,264), 843.
This item therefore *fails* of adoption lacking 445 affirmative votes.

*Vote III.* (Committee's version of Subsection 7 (*b*))
In favour .......... 540
Against .......... 758
Total valid ballots cast .......... 1,298
Affirmative votes required (2/3 of 1,298), 866.
This item therefore *fails* of adoption lacking 326 affirmative votes.

*Vote IV.* (Proposals not directly related to Consolidation, and affecting Sections 28 and 75 of the existing By-laws)
In favour .......... 1,150
Against .......... 227
Total valid ballots cast .......... 1,377
Affirmative votes required (2/3 of 1377), 918.
This item therefore *carries* by 232 votes.

As a result of these votes the proposals of the Committee on Consolidation fail to carry, and Sections 28 and 75 of the By-laws are amended to read as follows.

*Election and Transfer*

*Section 28.*—The council shall consider all the information with reference to each application, making further inquiries if deemed expedient, and shall then decide whether the application shall be accepted, and if so, to what class of membership the applicant shall be admitted. Before reaching this decision, however, not less than twenty-five of the forms referred to in section 27 must have been returned to the secretary, and the recommendations contained in these forms must be placed before council.

If five or more members of council oppose the admission or transfer of an applicant, he shall not be elected, otherwise **the affirmative** vote of three-quarters or more of those present **and** voting at a council meeting shall determine the classification of the applicant, with or without examination, and thereby constitute his election, subject to examination if so required.

A rejected candidate shall be notified promptly that his application has not been accepted, and he may renew his application for admission or transfer at any time after the expiration of one year from the date of his notification.

Application for membership in the class of Student shall be passed upon by council without the formality of notification to all councillors.

Amendments

*Section 75.*—(*a*) Proposals to introduce new by-laws or to amend or repeal existing by-laws shall be presented in writing to the council, signed by at least twenty corporate members, and shall reach the secretary not later than the first day of October. The council shall consider the proposals and the proposers shall be notified of the opinion of the council in regard thereto not later than the seventh day of November. The proposers may then withdraw their proposals, accept any changes suggested, or insist on the original form, sending their decision to the secretary not later than the fifteenth day of December. The proposals, as accepted by the proposers, shall be mailed to corporate members not less than twenty-one days before the annual general meeting. Proposals to introduce new by-laws or to amend or repeal existing by-laws, may also be made by the council and shall be mailed to corporate members not less than twenty-one days before the annual general meeting.

All proposals shall be submitted for discussion at the annual general meeting; the members there present may propose an amendment or amedments thereto, and all proposals together with such amendment or amendments **as are approved by the annual general meeting** shall be printed on a letter ballot to be submitted to the corporate membership of The Institute. The secretary shall issue the letter ballot not later than two months after the annual general meeting. The reasons advanced for and against the proposals edited by a committee appointed by the chairman consisting of an equal number of members favouring and members opposing the proposals shall accompany the letter ballot. The letter ballot shall be returnable to the secretary not later than three months after the annual general meeting. Scrutineers appointed by the council shall immediately thereafter count the ballots and report the result to the council.

An affirmative vote of two-thirds of all valid ballots shall be necessary for the amendment or repeal of existing by-laws, or for the adoption of new by-laws.

The by-laws as revised shall take effect forthwith, except that changes affecting the tenure of office of an officer of The Institute shall not take effect until the next annual election.

**(*b*) Notwithstanding anything to the contrary in this Section, the council may, at intervals of three years, strictly for purposes of clarification and simplification, reword any by-law or rearrange the by-laws. Such re-wording and/or re-arrangement shall become effective if and when it has been (*a*) approved by a majority of members of the council upon letter-ballot, (*b*) approved by the resolutions of the executive committees of a majority of The Institute Branches, (*c*) published in The Journal, and (*d*) finally approved, upon a formal motion to that effect, at a regular business session of an annual general meeting of The Institute.**

## International Conference on High Tension Electric Systems

The ninth biennial session of the International Conference on High Tension Electric Systems (C.I.G.R.E.) will take place in Paris from June 24th to July 2nd, 1937. This permanent organization was created in 1921 under the auspices of the International Electrotechnical Commission and its sessions are attended by delegates from different countries for the discussion of problems relating to the design, construction and operation of high tension electric systems. In 1935 there was an attendance of more than 1,200 representatives, largely from government departments and engineering and scientific organizations. At the forthcoming session in Paris over 100 technical papers will be presented from twenty different countries. Information regarding the conference may be obtained from Mr. F. Attwood, 50 Church Street, New York City, the President of the U.S. National Committee of the C.I.G.R.E.

## Special General Meeting of The Institute Monday, June 21st, 1937

The Council hereby gives notice that in accordance with Section 42 of the By-laws a *Special General Meeting of The Institute will be held at Headquarters at 10 a.m. on Monday, June 21st, 1937.*

The request for this meeting is dated April 30th, 1937, and reads as follows:—

> "We, the undersigned corporate members of The Engineering Institute of Canada, hereby request that a Special General Meeting of The Institute be called on Wednesday, June 16th, 1937, at 9.15 a.m., in a suitable room in the Windsor Hotel, Montreal, *for the purpose of receiving and discussing the results of the ballot on the By-laws of The Institute returnable on April 20th, 1937, and for the consideration of the general policy and administration of The Institute and for the taking of such action relative to the above matters as the meeting may consider to be in the best interests of The Institute,* all in accordance with Section No. 42 of the By-laws."

It is signed by the following sixty-one corporate members in good standing:—

| | | |
|---|---|---|
| P. E. Doncaster | M. H. Jones | James Weir |
| Geo. H. Burbidge | W. R. Hughson | Chas. M. McKergow |
| Hartvik Os | Dan Anderson | G. J. Dodd |
| H. G. O'Leary | A. D. Harrison | R. DeL. French |
| K. A. Dunphy | W. L. Malcolm | J. L. Bieler |
| C. B. Symes | A. Macphail | E. V. Gage |
| A. L. Pierce | A. Jackson | Ernest Cormier |
| A. J. Mickelson | Robert F. Legget | H. L. Briggs |
| J. Antonisen | L. F. Grant | Chas. T. Barnes |
| G. R. McLennan | Horace H. Lawson | R. H. Andrews |
| Walter Jackson | W. P. Wilgar | A. J. Taunton |
| G. H. Wood | D. S. Ellis | T. C. Main |
| C. G. Cline | Gordon McL. Pitts | Brian R. Perry |
| Geo. E. Griffiths | A. Turner Bone | J. Chas. Day |
| A. W. F. McQueen | L. R. McCurdy | W. G. Hunt |
| Jasper H. Ings | E. Viens | John G. Hall |
| Eric C. Molke | R. W. Boyle | L. H. Birkett |
| R. C. McMordie | C. MacL. Pitts | G. Lorne Wiggs |
| H. M. King | S. D. MacNab | Alexander Wilson |
| W. D. Bracken | F. M. Wood | Jas. A. Kearns |
| C. G. Moon | | |

The above request was received and considered by Council at its meeting on Friday, April 30th, 1937. It was noted that on June 16th, the date suggested in the request, members would be in attendance at the sessions of the Semicentennial Meeting. For this reason, in the opinion of Council, the purpose of the special meeting would be better served by holding it on the first date available after the close of the Semicentennial Celebrations, namely June 21st, and this date was accordingly selected.

R. J. Durley,
*Secretary.*

Montreal,
May 1st, 1937.

## The Eighth Plenary Meeting of Council

The result of the ballot on Consolidation and the future policy of The Institute in connection with that important question, will be the principal item on the agenda for the Plenary Meeting of Council which has been called for Monday, June 14th, the day before the commencement of the Semicentennial Celebrations. This date was chosen to take advantage of the presence of many members of Council, and thus secure a fully representative gathering.

# OBITUARIES

## Robert Neale Blackburn, M.E.I.C.

It is with regret that we place on record the death of Robert Neale Blackburn, M.E.I.C., which took place at Ross-on-Wye, England, on March 31st, 1937.

Mr. Blackburn was born at Sefton, Lancashire, England, on September 1st, 1866, and was educated at the Liverpool School of Science, obtaining a Whitworth Scholarship in 1887. He took first class honours in mechanical engineering at the City and Guilds of London Institute

Robert Neale Blackburn, M.E.I.C.

in 1888. Mr. Blackburn served a six years' apprenticeship in the works of George Forrester and Company, Liverpool, and was for seven years with Thornewill and Warham, at Burton on Trent, becoming chief draughtsman in 1901. He was subsequently for five years engaged in private practice as a consulting engineer in Liverpool. Coming to Canada, Mr. Blackburn entered the service of the provincial government of Saskatchewan in 1908, as boiler inspector, and three years later was appointed Chief Inspector of Steam Boilers. In 1924 Mr. Blackburn became Chief Mechanical Superintendent, Department of Public Works, Saskatchewan, holding that office until he retired in 1931. During his official career at Regina, Mr. Blackburn's technical advice was sought on many important engineering questions affecting the welfare of the province, more particularly as regards the utilization of local fuel resources, the generation and distribution of electric power and the problem of water supply.

Mr. Blackburn joined The Institute as a Member on April 27th, 1920, and became a Life Member on December 15th, 1931. He took a keen interest in Institute affairs, having served as chairman of the Saskatchewan Branch, and as representative of that Branch on the Council of The Institute during the years 1923 to 1925.

## John Vickers Angus, A.M.E.I.C.

It is with deep regret that we place on record the sudden death in Montreal, on April 8th, 1937, of John Vickers Angus, A.M.E.I.C.

Mr. Angus was born at Stocksfield-on-Tyne, England, on March 29th, 1889, and was educated at Sheffield University, Rutherford College, Newcastle, and Armstrong College, Durham University. He was apprenticed to the Wallsend Slipway and Engineering Company Limited, shipbuilders and engineers, from 1907 to 1911, and from 1911 until 1914 was assistant superintending engineer with Ellerman Lines Limited. From 1914 to 1919 Mr. Angus was engineer officer in charge of machinery afloat in the Naval Reserve and Merchant services, and saw much active service, his experiences including that of being torpedoed. After the war Mr. Angus was for a year efficiency engineer with the Manchester Steam Users Association, and in 1921 became associated with the Armstrong Whitworth Company, coming to Canada in the same year as assistant general manager of their Canadian Company. In 1923 Mr. Angus returned to England and was assistant to the manager of the Disposal Corporation, the British Government organization that was responsible for the disposal of surplus war machinery, being in charge of the sale, removal and installation of power plant and other equipment until 1927. In that year he joined the staff of the Montreal Engineering Company, acting as their purchasing agent in London until 1929. He then returned to Canada as chief mechanical engineer, which position he held until his untimely death.

Mr. Angus joined The Institute as an Associate Member on March 21st, 1922.

## Frank D. Anthony, M.E.I.C.

It is with deep regret that we place on record the death at West Chicago, Ill., on March 16th, 1937, of Frank D. Anthony, M.E.I.C., a member of The Institute of many years' standing.

Mr. Anthony was born at Hamilton Mine, Michigan, on December 30th, 1860, and commenced his career with the Chicago and Northwestern and the Minneapolis, Sault Ste. Marie and Atlantic Railways, filling positions ranging from chainman to construction engineer. From 1888 until 1890 he was principal assistant engineer with the Duluth South Shore and Atlantic Railway, and in 1891 was engineer in charge of ore docks in Cuba for the Sigua Iron Company. In 1892 Mr. Anthony was in Guatemala as chief engineer with the Ferro Carril del Norte, and during the following three years was in charge of construction with the Duluth Mesal a and Northern, and other railways, at Duluth. Mr. Anthony was next, in 1896-1899, chief engineer with the New York and Ottawa Railway, and then became special engineer in charge of construction of a large ore dock at Superior, Wisconsin, for the Great Northern Railway. In 1900-1901 he was bridge engineer with the Algoma Central Railway, and for the next year was division engineer with the Cape Breton Railway. In 1902 Mr. Anthony became chief engineer for the Quebec Southern Railway. Later he joined the staff of the Delaware and Hudson Railway Company, being construction engineer and later general fire inspector with that organization. He retired in 1928.

Mr. Anthony joined The Institute (then the Canadian Society of Civil Engineers) as a Member on December 18th, 1902, and was subsequently placed on the Life Membership List.

## Geoffrey Robertson Milne, S.E.I.C.

It is with deep regret that we place on record the death by drowning at Sorel, Que., on April 23rd, 1937, of Geoffrey Robertson Milne, S.E.I.C. Mr. Milne jumped to the rescue of a deck-hand who fell overboard, and both were drowned.

Mr. Milne was born at Newcastle-on-Tyne, England, on October 30th, 1901, and was educated in that country. He was for several years structural draughtsman with the Welland Ship canal at St. Catharines, Ontario, and later joined the staff of Lambert and German, naval architects, Montreal. In 1930 Mr. Milne became connected with the Manseau Shipyards Limited, and remained with that company until his untimely death, having been made assistant superintendent of the company in 1935.

Mr. Milne became a Student of The Institute on December 21st, 1921.

### John Thomas Morkill, M.E.I.C.

It is with regret that we place on record the death at Sherbrooke, Que., on April 14th, 1937, of John Thomas Morkill, M.E.I.C., a member of The Institute of many years standing.

Mr. Morkill was born at Sherbrooke, Que., on June 10th, 1856, and in the spring of 1874 began his engineering career as a rodman with the Quebec Central Railway. Later he acted as leveller and transitman on construction, and subsequently became an assistant engineer on construction. In 1881 he went to Brazil and was an assistant on the construction of the Imperial Brazilian Natal and Nova Cruz Railway; in 1883 and 1884 he was engaged on railway work in Nova Scotia. In the latter year he again joined the staff of the Quebec Central Railway, becoming chief engineer of that organization in 1905. Mr. Morkill's work took him to many parts of the continent, and he was at various times located in Nevada, Idaho, California, British Columbia, New Brunswick, Ontario and Quebec. In later years, Mr. Morkill was engaged in private practice in Sherbrooke.

Mr. Morkill joined The Institute (then the Canadian Society of Civil Engineers) as a Member on March 22nd, 1888, and became a life member on January 18th, 1928.

### Arthur Langley Mudge, M.E.I.C.

The membership of The Institute will learn with regret of the death at Toronto on April 29th, 1937, of Arthur Langley Mudge, M.E.I.C.

Mr. Mudge was born at Montreal on October 17th, 1873, and was educated at the Montreal High School and McGill University, graduating from the latter institution in mechanical engineering in 1894 and in electrical engineering in 1895. He spent some years in Canada and the United States in electrical testing, construction, estimating etc., and from 1899 to 1901 was electrical engineer to the Grand Trunk Railway, with headquarters at Montreal. In 1908 Mr. Mudge joined the staff of the consulting engineering firm of Smith, Kerry and Chace, of Toronto. For fifteen years he devoted his attention mainly to water power development and industrial electrical engineering, during which time he acted as chief electrical engineer on such works as the series of water power developments on the Trent river, the Calgary Power Company development at Horseshoe Falls, the Matabitchouan plant in northern Ontario, and the Calabogie Light and Power Company project on the Madawaska river. In 1925 Mr. Mudge was appointed power plant engineer on the staff of the Canadian section of the Joint Engineering Board of the St. Lawrence Deep Waterways Project, and in the same year joined the service of the Department of Railways and Canals at Ottawa. He subsequently became senior electrical engineer for the Welland Ship Canal at St. Catharines, Ontario, retiring from that office about three years ago to settle near Toronto.

Mr. Mudge, who was the first president of the Canadian Electrical Association, and a past-chairman of the Toronto section of the American Institute of Electrical Engineers, was also very active in Institute affairs.

He was a member of The Institute of many years standing, having joined as a Student on March 29th, 1894. He became an Associate Member on March 15th, 1899, and a Member on September 15th, 1925.

## PERSONALS

R. Weir, A.M.E.I.C., has recently been appointed industrial sales engineer for the province of Quebec by Imperial Oil Limited. Mr. Weir has been with that company for the past four years.

H. W. Tooker, A.M.E.I.C., was recently elected chairman of the Calgary Branch of The Institute. Mr. Tooker is in the Divisional Engineer's Office of the Canadian National Railways at Calgary, Alta.

A. U. Sanderson, A.M.E.I.C., chief engineer, Water Supply Section, Department of Works of the City of Toronto, has been elected chairman of the Toronto Branch of The Institute for the current year.

J. G. Chenevert, M.E.I.C., and E. Nenniger, A.M.E.I.C., have recently become partners in the firm of Arthur Surveyer and Company, consulting engineers, Montreal.

Mr. Chenevert graduated from the Ecole Polytechnique, Montreal, with the degree of B.A.Sc. in 1923, and has been associated with the organization of which he now becomes a partner, since that time.

Mr. Nenniger graduated from the Technical School at Burgdorf in 1921, and following graduation was for several years designing engineer in the office of W. Schreck, Dipl.

J. G. Chenevert, M.E.I.C.

E. Nenniger, A.M.E.I.C.

Ing. in Switzerland. He came to Canada in 1923, and joined Dr. Surveyer's staff in the same year.

Arthur Piché, Jr.E.I.C., who is on the staff of the Department of Public Works of Canada, has been transferred from Terrebonne to Quebec, Que. Mr. Piché graduated from the Ecole Polytechnique, Montreal, in 1930, and later was combustion engineer with Anthracite Coal Service, Montreal. In 1935 he was an engineer with the Department of Agriculture at Victoriaville, Que.

Alexander Rose, s.e.i.c., is now employed as assistant in the leather laboratories of the Division of Chemistry, National Research Council, Ottawa. He was previously connected with Donald-Hunt Limited, and Canadian Copper Refiners, Limited.

E. V. Buchanan, m.e.i.c., general manager of the Public Utilities Commission, London, Ontario, was elected chairman of the Canadian Section of the American Water Works Association, at the meeting of that organization held recently in Montreal.

Virgil S. Upton, s.e.i.c., has joined the staff of Bennett Aircraft Incorporated at San Fernando, Calif. Mr. Upton, who was formerly with the Noorduyn Aircraft Company at St. Laurent, Que., graduated from the University of Saskatchewan in 1935, with the degree of B.Sc.

Bernard Collitt, m.e.i.c., metallurgist for Jenkins Brothers Limited, Montreal, was elected chairman of the Montreal Chapter of the American Society for Metals at the Annual Meeting of the Chapter held on May 3rd.

C. E. Garnett, m.e.i.c., vice-president of Gorman's Limited, Edmonton, Alta., was elected President of the Association of Professional Engineers of Alberta, at the annual meeting of the Association which was held on March 20th, 1937.

G. J. Jarrell, jr.e.i.c., has become connected with the Willard Storage Battery Company of Canada Limited, at Toronto, Ontario. Mr. Jarrell, who graduated from the University of Toronto in 1935 with the degree of B.A.Sc., was formerly with Beatty Brothers, at Fergus, Ontario.

E. G. Eggertson, a.m.e.i.c., has joined the staff of the American Gas and Electric Company, New York, N.Y., as assistant electrical engineer. Mr. Eggertson, who is a graduate of the University of Manitoba, was for a time with the Aluminum Company of America at Pittsburgh, Pa., and subsequently with the Safe Harbour Water Power Corporation, at Baltimore, Md.

F. Irvine, a.m.e.i.c., who was formerly assistant engineer with F. S. B. Heward and Company Limited, has become associated with Peacock Brothers Limited, Montreal. Mr. Irvine was at one time combustion engineer with the Cleaton Company (Canada) Limited, and then sales and service engineer with Affiliated Engineering Companies Limited.

T. Foulkes, jr.e.i.c., who recently became connected with Canadian Cottons Limited, at Valleyfield, Que., graduated from the University of New Brunswick in 1926 with the degree of B.Sc. Following graduation Mr. Foulkes took the students' test course with the Canadian General Electric Company and in 1927-1928 was in the induction motor engineering department of the same company. In 1928 he joined the staff of the Spruce Falls Power and Paper Company at Kapuskasing, Ont., and was engaged on general electrical maintenance and installation and in 1929 he became engineer on maintenance, which position he has held up to the present time.

R. Eric Crawford, a.m.e.i.c., has resigned from the advertising department of Dominion Engineering Company Limited to become assistant superintendent of the Bagley and Sewall Company, Watertown, N.Y. Mr. Crawford, after graduating from McGill University in 1922, joined the Dominion Engineering Company in the production department, from which he was transferred in turn to the estimating department and sales department, entering the advertising department in 1928.

Don B. Sommerville, jr.e.i.c., has joined the staff of the International Petroleum Company, and will be located at Talara, Peru. Mr. Sommerville graduated from the University of Toronto in 1935 with the degree of B.A.Sc. and in the same year was an instrumentman with the Geological Survey of Canada. In 1936 he was a draughtsman with the Department of National Defence, and subsequently was structural engineer with the Canadian Comstock Company.

F. H. Cothran, m.e.i.c., consulting engineer, Charlotte, N.C., has been elected President of the Piedmont and Northern Railway and the Durham and Southern Railway, with offices at Charlotte, North Carolina. Mr. Cothran was at one time vice-president of the Quebec Development Company, in charge of construction on the Saguenay river projects, and in 1929 was connected with the Beauharnois Construction Company, Beauharnois, Que.

At the Annual Meeting of the Canadian Institute of Mining and Metallurgy held in Montreal recently, Professor H. E. T. Haultain, m.e.i.c., professor of mining engineering at the University of Toronto, was the recipient of the Bruce Gold Medal for the year 1936. This medal, which was instituted by the Honourable Randolph Bruce, is awarded at the discretion of the Council of the Canadian Institute of Mining and Metallurgy to those who have made outstanding contributions to the arts of mining and milling.

W. E. Lovell, m.e.i.c., Professor of Electrical Engineering at the University of Saskatchewan, Saskatoon, Sask., was elected President of the Association of Professional Engineers of the Province of Saskatchewan, at the annual meeting of the Association which was held recently. Professor Lovell graduated from the University of Manitoba in 1921 with the degree of B.Sc., and was subsequently with the Manitoba Power Company. In 1923 he became assistant professor of electrical engineering at the University of Saskatchewan, and in 1928 received the appointment which he still holds.

Hugh J. Leitch, a.m.e.i.c., who was formerly manager of the warehouse department of the Dominion Bridge Company, Lachine, Que., is now manager of the Sault Structural Steel Company Limited, at Sault Ste. Marie, Ontario. Mr. Leitch graduated from McGill University in 1926 with the degree of B.Sc., and was subsequently resident engineer for the Steel Gates Company Limited, on the erection of the lock gates of the Welland Ship Canal. In 1929 he joined the staff of the Dominion Bridge Company as assistant engineer in the designing department, and in 1933 received the appointment from which he has now resigned.

W. S. Wilson, m.e.i.c., who has been Secretary-Treasurer of the Toronto Branch of The Institute since 1931, is now retiring from that office.

Mr. Wilson graduated from the University of Toronto in 1921 with the degree of B.A.Sc., having been overseas with the Canadian Expeditionary Force from 1915 to 1919, holding the ranks of lieutenant and captain. In 1921-1922 Mr. Wilson was engaged on estimating and supervising construction work with Wilson and Falconer, and in 1922-1923 was estimator with Dowling-Williams Limited. From 1923 until 1926 he was demonstrator in the Department of Engineering Drawing, University of Toronto, and in the following year was with R. W. H. Binnie, general contractor, as estimator. In 1927 Mr. Wilson was appointed secretary of the Faculty of Applied Science and Engineering of the University of Toronto, which position he still holds.

## Elections and Transfers

At the meeting of Council held on April 30th, 1937, the following elections and transfers were effected:

*Members*

OGILVIE, Gordon, Lt.-Col., C.M.G., Director (Civilian) of Munitions, Department of National Defence, Ottawa, Ont.

REID, Wilfrid Thomas, President, Crude Oil Engine and Engineering Co. Ltd., Montreal, Que.

*Associate Members*

DUGAS, Joseph Esdras Armand, B.A.Sc., C.E., (Ecole Polytech.), industrial lighting divn., Montreal Light, Heat and Power Cons., Montreal, Que.

MARCHAND, Raymond, B.A.Sc., C.E., (Ecole Polytech.), res. engr., Dept. of Roads, Province of Quebec, Quebec, Que.

MILLETT, Ralph Strathie, B.Sc., (Mech.), (N.S. Tech. Coll.), forest products engr., Forest Products Labs. of Canada, Ottawa, Ont.

SNAPE, John Ball, res. engr., Jasper National Park, Jasper, Alta.

WHITE, Arthur Floyd, transitman, Toronto, Hamilton & Buffalo Rly., Hamilton, Ont.

*Juniors*

DUNNE, Charles Vincent, B.Eng. (McGill Univ.), constrn. engr., E. B. Eddy Co., Hull, Que.

MARTIN, Gerald, B.A.Sc., C.E., (Ecole Polytech.), boiler designer, Dominion Bridge Co. Ltd., Montreal, Que.

MORENCY, John, B.A.Sc., C.E., (Ecole Polytech.), engr., Parkhill Gold Mines Ltd., Gold Par P.O., Wawa, Ont.

*Transferred from the class of Associate Member to that of Member*

WIGHTMAN, John Fredrick Carman, (Mt. Allison Univ.), town manager and engr., Kentville, N.S.

*Transferred from the class of Junior to that of Associate Member*

ANDREWES, William Edward, Capt., R.C.E., (Grad., R.M.C.), B.Sc., (McGill Univ.), District Engineer Officer, Mil. Dist. No. 1, London, Ont.

BLACKMORE, Cyril Leslie, B.Sc., (McGill Univ.), President, C. L. Blackmore & Co., 1118 St. Catherine St. West, Montreal, Que.

FOULKES, Thomas, B.Sc., (Univ. of N.B.), Canadian Cottons Ltd., Valleyfield, Que.

PAULSEN, Rudolph O., B.Sc., (Univ. of Man.), struct'l. dftsman., Toronto Iron Works, Eastern Ave., Toronto, Ont.

*Transferred from the class of Student to that of Associate Member*

CAREFOOT, Herbert Reginald, Fl.-Lieut., R.C.A.F., B.Sc., (Univ. of Sask.), R.C.A.F., Headquarters, Ottawa, Ont.

DORE, Richard Francis, B.Sc., (Queen's Univ.), junior topog'l. engr., Bureau of Economic Geology, Dept. of Mines and Resources, Ottawa, Ont.

SAVAGE, Palmer Ernest, B.Sc., M.Eng., (McGill Univ.), struct'l. designer, Dominion Bridge Co. Ltd., Montreal, Que.

*Transferred from the class of Student to that of Junior*

COLGAN, Patrick Joseph, B.Sc., (N.S. Tech. Coll.), Cosmos Imperial Mills, Yarmouth North, N.S.

DALE, John Clapham, B.Sc., (Univ. of Alta.), Canadian Utilities Ltd., Calgary, Alta.

WESELAKE, Edward Joseph, B.Sc., (Univ. of Man.), Ste. 1, 503½ Selkirk Ave., Winnipeg, Man.

*Students Admitted*

**Students at McGill University**

ALEXANDER, John Andrew, 209 Strathearn Ave., Montreal West, Que.
ARCHAMBAULT, George, 288 McDougall Ave., Outremont, Que.
BUBBIS, Morris Israel, 3471 Hutchison St., Montreal, Que.
CHENG, Roger Kee, 3480 Durocher St., Montreal, Que.
COLLINGWOOD, John C., 1441 Drummond St., Montreal, Que.
FOSTER, Ian McLeod, 4 Oldfield Ave., Montreal, Que.
HENRY, George Robert Stirling, 1508 Crescent St., Montreal, Que.
JONES, David Carlton, Central Y.M.C.A., Montreal, Que.
KILLAM, Frank Richard, 3651 Durocher St., Montreal, Que.
KING, Donald, 2242 Coursol St., Montreal, Que.
KINGSLAND, Edward Notman, 544 Lansdowne Ave., Westmount, Que.
LEBEL, Harry W. S., 3506 University St., Montreal, Que.
MACKAY, Norman Allison, 3506 University St., Montreal, Que.
MAGUIRE, James C., 755 Champagneur Ave., Outremont, Que.
MAHOUX, Raymond Jean, 9 St. Catherine St. W., Montreal Que.
MARTIN, Henri Milton, Jr., Annamoc Apts., Edmonton, Alta.
MOSELEY, Shirley Charles Tilton, 37 Bellingham Road, Outremont, Que.
NICHOLSON, John H., 175 Birch Ave., St. Lambert, Que.
PAYAN, Charles Frederick, 3437 Peel St., Montreal, Que.
PENGELLEY, C. Desmond, Tremorn, Mandeville, Jamaica, B.W.I.
SCRIVER, Bruce MacKenzie, 6000 Hutchison St., Montreal, Que.
SIMPSON, John Hamilton, 1703 William David St., Montreal, Que.
SPARKS, Roderick Fraser, 1441 Drummond St., Montreal, Que.

**Students at the University of Alberta**

ADAMSON, William Blackwood, 9137—84th Ave., Edmonton, Alta.
ALGOT, Clarence Aldo, Derwent, Alta.
BOGART, Evan Winston, 12341—128th Ave., Edmonton, Alta.
CHAMBERS, Robert, 7619—112th Ave., Edmonton, Alta.
CONNELL, Gordon Allen, 10646—125th St., Edmonton, Alta.
FORSYTHE, Marshall Anthony, Clover Bar, Alta.
HINDLE, Walter, 11649—95th St., Edmonton, Alta.
KIRKLAND, William Dalton, 10338—127th St., Edmonton, Alta.
KLODNISKI, Nick, 12512—125th St., Edmonton, Alta.
MARTIN, Tom Elbert, 10458—78th Ave., Edmonton, Alta.
WATERS, Donald Samuel Brooks, 804—16th St. N.W., Calgary, Alta.

**Students at Queen's University**

ALLAN, Robert Gage, 184 Barrie St., Kingston, Ont.
GILES, John Oscar, 111 Kathleen Ave., Sarnia, Ont.
MOLLAND, Fredrick William, Thorndale, Ont.
SANDERS, George Ostrom, 15 Union St., Kingston, Ont.
WILLIAMS, John Thomas, Queen's University, Kingston, Ont.

**Students at the University of Manitoba**

GERSHFIELD, Max, 371 College Ave., Winnipeg, Man.
ROBINSON, Arthur Harold, 149 Polson Ave., Winnipeg, Man.
SWAIN, Douglas Smith, 27 Fawcette Ave., Winnipeg, Man.
WHITE, William Barr, 1322 Wolseley Ave., Winnipeg, Man.

**Students at the University of New Brunswick:**

BAIRD, Malcolm Francis, 136 Aberdeen St., Fredericton, N.B.
DIBBLEE, Frederick Allan, Woodstock, N.B.
OLTS, George Lounsbury, 222 Waterloo Row, Fredericton, N.B.
RALPH, John Arthur, 96 Casot Ave., Quebec, Que.
RAWLAND, Arthur Gordon, 220 Brown Avenue, Quebec, Que.

* * *

BOUTILIER, Tremaine Thompson, B.Eng., (N.S. Tech. Coll.) Hammond's Plains, Halifax Co., N.S.
BROWN, Malcolm Corsan Sutherland, (R.M.C.), Bowker Place, Oak Bay, Victoria, B.C.
DRURY, Chipman Hazen, (R.M.C.), Kingston, Ont.
MacDONALD, George Elmer, B.Sc., (N.S. Tech. Coll.), Upper Musquodoboit, N.S.
McRAE, Robert Bruce, B.Sc., (Univ. of Alta.), 9842—87th Ave., Edmonton, Alta.
ROY, Joseph Albert Maurice, (R.M.C.), Kingston, Ont.
STEPHENSON, John Gray, (R.M.C.), Kingston, Ont.
WALLER, Jack Jason, B.Eng., (McGill Univ.), 3797 Decarie Blvd., Montreal, Que.

## The Late Dr. Elihu Thomson

Members of The Engineering Institute of Canada will learn with regret of the death at Swampscott, Mass. on March 13th, 1937, of Dr. Elihu Thomson, who was a brother of the late Frederick Thomson, M.E.I.C., of Montreal, who died on August 8th, 1936.

By the death of Dr. Thomson, world electrical engineering has lost one of its greatest and most widely-esteemed leaders, a man who for very many years through his scientific inventiveness, research and industry, contributed to the electrical advance which has been spread over the last fifty to sixty years.

Dr. Thomson was born in Manchester, England, in March 1853, and was brought to the United States at the age of five, in 1858. In 1880, Elihu Thomson and Dr. Houston, both of them teachers, began a collaboration which was destined to have far-reaching results. Dr. Thomson was the founder of the original Thomson-Houston Company, from which the B.T.H. Company developed. The manufacturing and associated operations of Thomson and Houston became so extensive by 1892 that it was decided to merge the organization with the Edison General Electric Company, the two businesses being combined under the title of the American company now so well known as the General Electric Company.

As is well known, honours fell to Dr. Thomson from all directions, the Royal Society awarded him the Hughes Medal, the Institution of Electrical Engineers the Faraday Medal, American Science the John Fritz Medal, and German engineers the Grashof Medal. He was an honorary member of the Institution of Electrical Engineers, the Institution of Civil Engineers and the Royal Institution; a past-president of the American Institute of Electrical Engineers, of the International Electrical Congress at St. Louis, and the International Electrotechnical Commission at Turin. He was also an officer of the Legion of Honour.

## CORRESPONDENCE

The Editor, March 31st, 1937.
The Engineering Journal,
Montreal.

Dear Sir:—

The paper published in the January issue of The Journal under the title "Heat Insulation for Buildings" by Professor E. A. Allcut is very interesting. We hope that everyone in Canada will eventually become acquainted with the importance of thermal insulation and the fuel savings possible through it.

There is one statement which seems to call for comment, namely, that the thermal conductivity varies with the thickness or size of the sample. If this is true, it will be very disturbing to engineers and architects who must use these figures in computing heating loads. Professor Allcut shows that he obtained different results on samples of different thicknesses. This can be due to either an actual change in the "$k$" value or to uncertainty in the measurements. In regard to the former, it is very difficult to understand in a material consisting of minute cells why the first inch should be different than the second or the succeeding inches of thickness. In respect to the latter explanation, it should be pointed out that with increasing thickness smaller heat transfers are involved and more difficulty is experienced in maintaining the parallel line of flow, or in other words, to prevent losses to or gains from the room. This, in other words, means a higher percentage error in the measurements. Professor Allcut recognizes this point as per his statement that "it was impossible to test a thick specimen in a small plate on account of the large edge losses that would be obtained." In this connection also, he points out "That the size of the apparatus in relation to the thickness of material should be standardized."

It is our belief that because of the two possible explanations of the differences it has not been shown that the "$k$" value varies with the thickness, and in as much as this conclusion is very disturbing, we should like to protest the point and consider it a matter requiring further investigation. We will appreciate having this note published.

Very sincerely yours,

H. C. Bates,
Chief, Fibre Products Laboratory

Corning Glass Works,
Corning, New York.

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The Editor, April 6th, 1937.
The Engineering Journal,
Montreal.

Dear Sir:—

In reply to Mr. Bates' letter dated March 31st, 1937, commenting on one aspect of my paper "Heat Insulation for Buildings," I may say that some years ago my attention was directed to the influence of thickness on the apparent heat conductivity of insulating materials, when I compared the results obtained by different laboratories on fibre boards of similar composition and density, but of different thicknesses. In all cases, higher values were obtained with increasing thickness. Similar tests made at the University of Toronto produced the same results, which are difficult to account for other than by the hypothesis of surface resistance. When the investigation was extended to include packed fibrous materials, we were surprised to find that in these cases also, the value of "$k$" increased with thickness. It was at once assumed that the results were wrong and several months were spent in checking the apparatus and technique, but no appreciable source of error was discovered. Since that time, numerous tests have been made on packed materials of different kinds and all of these have confirmed the original results.

I fully appreciate the force of Mr. Bates' arguments, but these results have been obtained repeatedly and a reasonable explanation must be found for them. The suggestion that edge losses are contributory factors does not apply in this case, as the edges of the large specimens were shielded from the atmosphere by thick insulation, and the mean temperature, in most cases, was very close to that of the atmosphere. There is some evidence, however, to indicate the presence of convection inside the specimens.

I agree with Mr. Bates that more experimental work is desirable and propose to continue this investigation during the summer of 1937. The detailed evidence obtained up to this date will be available in published form during May 1937.

The principal object of the paper, however, was not to compare one class of insulating material with another, as their relative merits are mostly unaffected, but to call attention to the need for proper standardization of the methods and apparatus for testing heat insulating materials so that the results obtained may be more valuable both for purposes of comparison and application.

Yours faithfully,

E. A. Allcut, m.e.i.c.

Department of Mechanical Engineering,
University of Toronto,
Toronto 5, Canada.

## Recent Additions to the Library

### Proceedings, Transactions, etc.

Institution of Water Engineers: Transactions, 1936.
Punjab Engineering Congress: Proceedings, 1936.
American Society of Civil Engineers: Transactions, 1936.

### Reports, etc.

*Dominion Bureau of Statistics:* Preliminary report on the Mineral Production of Canada, 1936.
*Port of New York Authority:* 16th Annual Report, December, 1936.
*National Parks of Canada:* Annual Report 1935-1936.
*American Institute of Consulting Engineers:* Constitution, By-laws and List of Members, 1937.
*New Brunswick Electric Power Commission:* 17th Annual Report, for the year ending October 31st, 1936.
*Quebec Bureau of Mines:* Annual Report 1935, Part A.
*Ontario, Dept. of Mines:* Preliminary Report on the Mineral Production of Ontario in 1936.
*National Harbours Board:* Annual Report, 1936.
*Nova Scotia Power Commission:* 17th Annual Report for the year ending November 30th, 1936.
*Montreal Board of Trade:* Report of Special Committee appointed to study the basis of motor truck registration and regulations governing highway transportation in the province of Quebec.
*Institute of Radio Engineers:* Year Book 1937.
*Dominion Bureau of Statistics:* Transportation and Public Utilities Branch: Central Electric Stations in Canada, 1936.
*City of Winnipeg Hydro Electric System:* Annual Report 1936.
*U.S. Dept. of the Interior, Bureau of Mines:* Questions and Answers on Boiler Feed-Water Conditioning.
*Association of Professional Engineers of B.C.:* Tree Heights from Air Photographs by Simple Parallax Measurements, by G. S. Andrews.
*American Association of State Highway Officials:*
Standard Specifications for Highway Bridges, 1935.
Standard Specifications for Arc Welding Metal Bridge Structures, 1935.

### Technical Books, etc.

History of Munitions Supply in Canada, 1914-1918, by D. Carnegie (*Longmans, Green and Company.*)
Metallic Corrosion Passivity and Protection, by Ulick R. Evans (*Edward Arnold and Company, London.*) (*Longmans, Green and Company, Toronto.*)

## BULLETINS

*Water Tube Boilers.*—An 8-page pamphlet issued from Canadian Vickers Limited, Montreal, gives details of their Vickers-Keeler water tube boilers. Seven different types of furnace arrangement are illustrated. It is stated that these can be modified to meet the requirements of any type of combustion equipment.

*Motor Truck Scales.*—Canadian Fairbanks Morse Company Ltd., Sherbrooke, Que., have issued a 6-page folder describing their type S motor-truck beam scales. These are made in capacities of 10 to 20 tons, with varying sizes of platforms.

*Motors.*—A 6-page bulletin, No. 42, received from Bepco Canada Ltd., Montreal, illustrates their Corcooled motor. This is manufactured by the Lancashire Dynamo and Crypto Ltd. and is a totally enclosed motor produced for both a.c. and d.c. types, available in either squirrel cage or slip ring type from 30 h.p. upwards.

*Pumps.*—The Worthington Pump and Machinery Corporation, Harrison, N.J., have issued a 4-page leaflet describing their balanced multi-stage volute centrifugal pumps for boiler feed service in three sizes with capacities from 200 to 1,500 r.p.m., pressures up to 1,200 lb. per sq. in.

*Motors.*—A 4-page circular received from the Canadian General Electric Company Limited describes their high-speed synchronous motors, 7,000 series, manufactured in a large range of sizes from 25 to 200 h.p. with varying r.p.m.s.

*Caterpillar Diesels.*—A 12-page booklet received from the Caterpillar Tractor Company, Peoria, Ill., illustrates the various uses of Caterpillar Diesels in connection with the construction of roads.

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The March number of the Royal Engineers' Journal contains an interesting and complete article on "Coast Protection on the North Sea Coasts of Holland, France, Belgium and Germany." The author, Mr. van der Burgt, is engineer of the Netherlands State Waterways Administration, and the article has been translated and printed by permission from "De Ingenieur." The problem of coast protection is a vital one in Holland, and the paper, which is fully illustrated, forms a remarkable record of the achievements of Dutch engineers in this class of work. Reprints of the paper may be had from the Editor, Royal Engineers Journal, Chatham, Kent, England, at the cost of 2s. 6d. post free.

## BOOK REVIEWS

### Cyanidation and Concentration of Gold and Silver Ores

*By John Van Nostrand Dorr. McGraw-Hill Book Company, New York. 1936. 6 by 9¼ inches. $5.00. Cloth. 485 pages.*

Mr. Dorr's achievements in the development of the art of cyanidation and concentration are so outstanding as to win for him the admiration and respect of all interested in the industry. It is indeed fortunate that he has been able to find time to write a book which, as was to be expected, is excellent.

Following an introductory historical chapter, is a discussion of the examination and testing of ores. Four chapters follow in which the preparation of ore for cyanidation is covered by a description of coarse crushing, sorting, fine grinding and classification. Sand and slime treatment are fully considered and in this is included a description of types of equipment and examples of practice. Concentration of ores and treatment of concentrates, bullion recovery and plant control are covered in three rather extensive chapters. Of interest is the section on the treatment of simple and complex ores which includes descriptions of plant equipment and numerous flow sheets, in which particulars are given for some fifty mills in all parts of the world, handling a large variety of ores. Treatment of old residues is covered in a further chapter and costs and power consumption receive considerable attention details being given for a large number of mills. Chapter 15 contains useful reference information and includes a table of elements, general conversion factors, a list of metals and minerals based on information from Dana's text book of mineralogy, tables on slime density relations, and finally a list of books on cyanidation.

### Engineering Geology

*By H. Ries and the late Thos. L. Watson. John Wiley and Sons Inc., New York (Renouf Publishing Company, Montreal). 1936. 6¼ by 9¼ in. $5.00. 750 pages. Cloth.*

Engineering Geology was first published in 1914, and a fourth edition appeared in 1931. The present, the fifth edition, comprises nineteen chapters, and has been considerably revised, with new bibliographical references added. This volume contains an excellent presentation of the fundamental principles of geology relating to engineering problems.

The opening chapter covers rock forming minerals, and is followed by one dealing with rocks, their general characters, mode of occurrence and origin. Chapters on the structural features of rock will be of particular interest to engineers as well as those on rock weathering and soils. Surface and sub-surface waters, landslides and land subsidence, wave action and shore occurrence, the origin and structure of lakes and glacial deposits are comprehensively covered. Chapter II, on the geology of reservoirs and dam sites is new, the author stating that "the geologic examination of reservoirs and dam sites has within the last few years become a matter of recognized importance, its necessity having been well emphasized by the leakage from a number of reservoirs or the failure of dam sites due to unfavourable geologic conditions."

Building stone, lime, cement and plaster, and clay and clay products are covered in three chapters of some one hundred pages and chapters on coal series, the micro-constituents of coal, types of coal and effect of constituents, petroleum, natural gas and other hydro carbons follow.

The closing chapters cover road foundations and materials, ore deposits and historical geology.

The book is printed on good quality paper and the type is easy to read. The contents are well indexed.

Practising engineers who have problems related to geology might well add this volume to their library.

## Symposium on the Burning of Canadian Coal at Semicentennial Meeting

### Summaries of Papers to be Presented

#### British Columbia Coals in Metallurgy

*R. R. McNaughton*

This paper sketches the distribution and character of British Columbia coal fields in which the coals range from lignite to high carbon bituminous, many of the latter coals being suitable for coking. Factors influencing the selection of coals are covered in some detail, also the application of coal in metallurgy. Factors involved in the design of a powdered coal plant are described, and the advantages and disadvantages of types of equipment are discussed.

#### The Burning of Low Rank Alberta Coals, The Steam Generating Plant

*Professor C. A. Robb, M.E.I.C.*

The author deals with the development of the steam generating plant in central electric stations burning low rank Alberta coals. He discusses plants and their equipment with performance data and trends in design. At the end of 1934 the installed capacity of fuel burning stations was 166,959 kv.a. and the kilowatt hours generated, 185,865,000. One of the largest steam generators in Canada is in operation at a Regina plant, and consists of a bent tube boiler, combination superheater and a tubular air preheater. The furnace has one steam-cooled and three water-cooled walls, and may be fired by pulverized fuel or gas or both. Bituminous coal or lignite is prepared by a unit system.

#### The Burning of Low Rank Alberta Coals, Combustion and Control

*Edgar Stansfield, M.E.I.C.*

This paper presents recent developments in the methods and conception of coal analysis, and with their significance in combustion problems, and provides data relative to combustion. Coals taken as samples are all from Alberta, but the discussion is applicable to the combustion of any coal. The low rank coals are studied by comparison with those of high rank.

#### Experience in Burning Western Canadian Coals

*E. W. Bull*

This paper covers experiences in burning coal lignites and bituminous coal with stokers and pulverized fuel equipment installed in the Regina power plant. This plant started originally with underfeed stoker fired boilers operating at 200 lb. pressure, but is now equipped with modern pulverized fuel equipment.

#### The Saskatchewan Lignite Industry

*R. L. Sutherland*

The author describes recent developments in the Saskatchewan lignite industry and the effect of production methods on employment and the earnings of labour. This industry owes its existence to its geographical position and proximity to the most densely populated area of the Prairie Provinces, and its future development will depend on the extent to which production methods are adopted which require minimum capital investment in relation to the production value, and which at the same time reduces the present seasonal fluctuation in employment to a minimum. The annual production has increased from about 500,000 tons to more than a million tons since 1929, which has been effected in competition with coal from other western provinces and imported from western lake ports. The author gives reasons for the increased use of lignite in industrial plants, and outlines the expansion of mining plants to produce increased tonnage. In the author's opinion the experience of the past seven years indicates that stabilization of the industry to ensure fair wages, a fair return to the operator and value to the customer can best be effected if certain definite policies which he outlines are followed.

#### Characteristics and Qualities of Nova Scotian Coals

*F. H. Sexton*

The excellent bituminous coals in Nova Scotia are the basis of a large industry which supports some 60,000 people, and due to the fact that the St. Lawrence river offers a means of cheap transportation, Nova Scotian producers are able to supply most of the soft coal requirements from the Maritime Provinces to Montreal. There has been a dearth of technical and scientific data concerning Nova Scotia coals, as while an extensive investigation was made some twenty years ago, conditions to-day are somewhat different. Recent investigations, however, conducted at the Nova Scotia Technical College cover tests and trials of four different kinds, and include chemical analyses, standard boiler trials, a series of efficiency trials in hot-water boilers for domestic heating, and weathering tests of stored coal. The results of these extensive tests are given in detail by the author.

#### The Economic Use of New Brunswick Coal

*John Stephens, D.Sc., M.E.I.C.*

The workings of the New Brunswick coal field are the oldest in North America, but the output has so far not exceeded 900,000 tons a year. The coal, while in general local use for railway and industrial purposes, has been described previously as a difficult coal to handle continuously at high ratings. The author gives operation results, complete with cost data, on this coal used at the Grand Lake plant of the New Brunswick Hydro-Electric Power Commission, and proves that there is no physical difficulty in connection with its combustion. The average energy content of the coal used is 12,000 B.t.u. per lb. with an ash content of 16 per cent. With reasonable capital and maintenance costs a kilowatt can be produced with less than 1.6 lb. of fuel.

#### Some Observations on the Use of Bituminous Coal as Locomotive Fuel

*John Roberts*

The purchasing, distribution and economical consumption of coal on any large railway system presents a complex problem as may be gauged by the fact that the total coal bill for the Canadian National system for 1936 amounted to over $18,000,000. The quality of the coal obtained from the many different seams varies widely, and the resulting problems of the mechanical and fuel departments of the railway are discussed in the paper. The author gives an explanation of the modern locomotive boiler and describes its evolution over the past one hundred years. Combustion conditions and locomotive services are entirely different from those in any other type of steam generator, for in addition to providing for efficient generation of steam, other difficulties have to be faced, such as fire hazard and smoke nuisance. The fuel consumption of the Canadian National Railways per 1,000 gross ton miles from 1923 to 1936 amounted to over 22 per cent, notwithstanding the adverse effect of high operating expenditure. During this period the average freight train speed increased by over 39 per cent.

# BRANCH NEWS

## Border Cities Branch

*J. F. Bridge, A.M.E.I.C., Secretary-Treasurer.*
*F. J. Ryder, Jr.E.I.C., Branch News Editor.*

### The Future of Private Aviation

The March monthly meeting of the Border Cities Branch of The Institute was held in the Prince Edward hotel, Friday, March 19th, 1937, at 6.30 p.m.

Dinner was served to fourteen people, three of whom were visitors. Twenty-one attended the lecture immediately afterwards.

Minutes of the February meeting were read and adopted. C. F. Davison, A.M.E.I.C., chairman, presided.

Dr. H. F. Gerhardt, Professor of Aero Engineering, Wayne University, Detroit, was introduced by Boyd Candlish, A.M.E.I.C., as the speaker of the evening, and had as his subject, "The Future of Private Aviation." He traced the history of aviation from the time man first tried to fly by imitating the action of birds on the wing to the present day planes. He pointed out that it was hopeless for man to ever expect to fly by his own power, as his weight per horse power developed was in the range of 2,400 to one, whereas it has been found that with most recent planes, this bears the ratio of 1½ lb. per hp.

Dr. Gerhardt pointed out that the future private plane must be an automobile with aerodynamic accessories, so that it could be used for land transportation and go into the air occasionally. It must be capable of vertical ascent and descent, and have folding or removable wings which could be stored at the hangar. He was firmly of the opinion that the miniature plane was not the answer to private aviation. The lecture was illustrated by slides.

A hearty vote of thanks was moved by Mr. Porter and tendered to the speaker by the chairman.

Meeting adjourned at 10.30 p.m.

The regular monthly dinner meeting of the Border Cities Branch was held in the Prince Edward hotel, on Friday evening, April 16th, 1937, with nineteen persons present.

O. M. Perry, M.E.I.C., introduced the speaker for the evening, Professor Levy of Toronto, who is well known for his lectures and practise in psychology. Professor Levy's subject was "The Human Map Speaks for Itself."

As a psychologist, Professor Levy has been practising for thirty-eight years. He does not claim infallibility for his profession, but does claim that it is the best method of determining the characteristics of a man and how to judge that man from them.

Modern psychologists have three methods of judging man:

1. The Imperial method is mainly guess work as it depends upon the ability of the psychologist to judge a person from outward physical signs only. This is not used much as there is too much guess work.
2. The anthropathological method is the science of determining man's characteristics biologically and ethnographically.
3. The Psychological method considers the first two methods along with certain definite tests and measurements.

If any of the laws of God or man are broken by a person it has its effect on their characteristics, to the psychologist, the posture, walk, tone of voice, laughter, cleanliness of body and any outward peculiarities all mean something. (However, they must be considered in relation with other tests.)

The most important part of the psychologists work is the corelating of the tests and observations so as to deduce the correct result.

Professor Levy has been employed by a good number of firms to study the characteristics of their employees in order to ascertain their best qualities and to place them where they are best fitted.

C. M. Goodrich, M.E.I.C., moved a hearty vote of thanks which was seconded by W. H. Baltzell, M.E.I.C., and heartily approved by all.

## Hamilton Branch

*A. R. Hannaford, A.M.E.I.C., Secretary-Treasurer.*
*W. W. Preston, S.E.I.C., Branch News Editor.*

The annual joint meeting of the Hamilton Branch of The Institute and the Toronto Section of the American Institute of Electrical Engineers was held on April 9th, 1937, in the Westinghouse auditorium.

On this evening the engineers were the guests of the Canadian Westinghouse Company and the speaker was Dr. L. W. Chubb, Director of Research, Westinghouse Electric and Manufacturing Company, Pittsburg. His subject was entitled Industrial Progress Through Science and Research and was illustrated.

The attendance at this meeting was 293.

The opening remarks of Dr. Chubb pointed out that there is no "last word" in achievement and the time will not likely come when the engineer finds there is nothing for him to improve. Ideas are continually ripening from what has gone before and hindsight is better than foresight. Through improvements developed in the laboratories of our universities and industries by science and research, we are ever pushing back the frontiers of industry.

Frequently the problem of the research engineer is to develop a new material or process. If there is not a suitable metal for the job on the market, the metallurgist is given the desired properties and asked to make a new alloy. Indeed, metallurgy has developed from an art to a science.

In the car industry, Dr. Chubb stated that a heat treatment used to take half an hour but has been reduced to eight minutes as a result of a scientific investigation.

Another field of research is found in the study of the fundamentals of science. It is a long term work; there is no immediate application of such knowledge to industry, and the only justification for undertaking it, is the hope that continual study will reveal its usefulness. Just as Neon rose from a laboratory curiosity to a commercial product, so it is hoped that present investigations on the breaking of atoms will some day have commercial value.

Dr. Chubb concluded his address with a number of illustrations and demonstrations showing the results of research. He referred to the Streule lamp used in the operating room to prevent infection and after operation fever. Several experiments with polarized light proved very interesting. Particular stress was given to the application of polarized light to automobiles, as a means of eliminating head light glare. The speaker said that when light falls on a polar screen, that part of the light which lies in one certain plane passes through and the rest is absorbed or dissipated as heat. If these screens were placed on the head lights of all cars so that the emitted light left in a plane of forty five degrees to the vertical; rising from the left wheels to the right; and if the driver looked through another screen similarly oriented, then, the lights from his own headlights would be visible to him. The two screens are placed to pass light in a given plane.

Though the headlights of both cars emit light in the same plane the light of the approaching car is absorbed in the screen before the driver's eyes.

The safety feature of this scheme is very desirable but it has the disadvantage that one half of the candle power of the lamps is not used.

A good discussion completed the work of the lecturer.

Colonel E. G. Mackay, A.M.E.I.C., chairman of the Hamilton Branch introduced Professor Smith, chairman of the A.I.E.E., and he in turn introduced the speaker.

W. B. Dunbar, A.M.E.I.C., moved a very hearty vote of thanks to Dr. Chubb for a most interesting evening which was then completed by a very delightful array of refreshments that had been prepared for all present by the kindness of our hosts.

## London Branch

*D. S. Scrymgeour, A.M.E.I.C., Secretary-Treasurer.*
*Jno. R. Rostron, A.M.E.I.C., Branch News Editor.*

The regular monthly meeting of the Branch was held on March 18th, 1937, in the Officers' Mess Room at the Armouries, Dundas Street, and the speaker was Mr. C. A. Cline, B.Sc. (O.A.C.), of Burlington Steel Company, Hamilton. The title of his address was "A Niagara Free Port."

The chairman of the Branch, A. O. Wolff, M.E.I.C., presided and after the reading of the minutes he introduced the speaker.

Mr. Cline commenced by defining a free port as a "Segregated area on which goods not otherwise prohibited may be unloaded and stored, subject to varying restrictions as to storing, grading, repacking, manipulation and manufacturing, and in which such goods or authorized manufactures therefrom may be reloaded and shipped to foreign destinations, all without the imposition of the customs formalities and duties applicable to similar goods entering customs territory."

In the speaker's opinion, the area between the Welland Ship canal and the United States border would form an ideal situation for such a port. It is centrally located with respect to the largest manufacturing districts in both Canada and the United States. Imported goods could be brought in from the Atlantic ports by rail during the winter and directly from the country of origin by vessel during the navigation season. Manufacturers would have an easily accessible place to visit for the inspection, selection and purchase of such commodities as they might want and no duty would be paid until such goods moved out of the area or were consumed by the local industries.

Shipping on the upper lakes should benefit from the location of a free port at such a point because West-bound cargoes would be available. Importers could bring in cargo lots at a minimum shipping charge because the tramp steamers would have a good prospect of a turn-around cargo of grain or flour to be picked up either at Niagara or further down the St. Lawrence. The load factor is the important point in this connection and will have to be given careful study but on prior investigations have indicated that it would prove favourable and that return cargoes would be available in the great majority of cases, particularly if the grain trade improves.

There is no question of such an area not remaining a part of Canada as national, provincial and municipal jurisdiction remain at present. The customs frontier only is affected. Immigration and all other dispositions are unchanged. Existing manufacturers and business of all kinds within the area enjoy their present facilities unimpaired. They benefit to the extent of a larger market and lower transportation charges—such a port has recently been established in New York Harbour.

Free ports are in operation at Hamburg (Germany), London (England), Hong Kong and at other places.

Essentially a free port is a legal device to permit a more free interchange of commodities, without lowering tariffs.

The establishment of a free port on the Niagara Peninsula would create employment by stimulating—

(a) The constructing industry.
(b) Increase in high classification business (package goods) for the lake freighters and the railways.
(c) Lower costs of raw materials to manufacturers.
(d) Enlargement of our export markets by giving ocean shipping facilities at our doors.

Taking the Port of Hamburg, Germany, as a successful free port, the factors contributing to the success are as follows—

(a) Few customs formalities.
(b) Favourable load factor.
(c) Traffic cross lane.
(d) Rich hinterland.
(e) Adjacent to and contiguous with customs frontier.
(f) Speed and capacity in handling cargo.
(g) Private capital finances and manager.

It was then shown that these factors were already present, or only needed adequate regulations and proper facilities to bring them into operation in the Niagara Peninsula.

Senate Bill E. 2 permits only one free port in each province, the claims of the Niagara Peninsula as the site of the Ontario free port merit every consideration. This bill also provides for the proper establishment, control, layout and management of such a port.

After an animated discussion, a vote of thanks was proposed to the speaker by S. W. Archibald, A.M.E.I.C., seconded by Murray Dillon, and unanimously carried.

About twenty members and guests were present.

## Montreal Branch

*E. R. Smallhorn, A.M.E.I.C., Secretary-Treasurer.*

### Special Meeting

On Thursday, April 1st, 1937, a special meeting of the Montreal Branch took place, called at the request of thirty corporate members, for the purpose of discussing the question of the consolidation of the Engineering Profession in Canada. The meeting was well attended, and an interesting and enlightening discussion took place.

Huet Massue, A.M.E.I.C., chairman of the Branch, was in the chair.

### Junior Section

H. E. Cunningham, S.E.I.C., who is with the Dominion Engineering Company, presented a paper on "Gears," and Louis Trudel, S.E.I.C., who is with the Quebec Electricity Commission, presented one on "An Actual Case of Research Work on Reduced Models of Spillways," at the meeting of the Junior Section of the Montreal Branch held on April 5th. Both papers proved to be extremely informative and interesting, and were illustrated by slides and motion pictures. Prior to the meeting an election took place, to fill the vacancy on the Executive Committee caused by the resignation of V. S. Upton, S.E.I.C., who has left Montreal. R. N. Warnock, Jr.E.I.C., was elected.

Jacques Hurtubise, S.E.I.C., was in the chair.

### The Production of Radio Active Substances

On Thursday, April 8th, Dr. J. S. Foster, F.R.S., Macdonald Professor of Physics at McGill University, presented a paper on "The Production of Radio Active Substances." Dr. Foster's address covered the difficulties confronting scientists studying radium and other radio active materials, recent achievements in the large scale production of neutrons, and the commercial development of radio active forms of common substances.

Professor R. E. Jamieson, M.E.I.C., was in the chair.

### The Problem of Economic Stability as Seen by an Engineer

At the meeting of the Montreal Branch held on April 15th, P. Ackerman, A.M.E.I.C., consulting engineer, Montreal, spoke on "The Problem of Economic Stability as Seen by an Engineer." Mr. Ackerman's talk covered an analysis of our economic system presented in engineering language by the use of simple mathematics and graphs, and indicated how the analytical tools of practical science could serve in obtaining a clearer understanding of this perplexing problem.

Professor C. V. Christie, M.E.I.C., acted as chairman.

### Junior Section

"Highway Development in Alberta" was the subject of an address by J. L. Pidoux, Jr.E.I.C., and "Elements of Modern Combustion Design" that of Mr. G. Martin, at the meeting of the Junior Section held on April 19th. Both of these talks, while brief, were most interesting and well illustrated.

The chairman was C. J. Pimenoff, S.E.I.C.

### The Adaptation of Rigid Structural Frames to Modern Construction

"The Adaptation of Rigid Structural Frames to Modern Construction" was the subject of a paper presented by E. R. Jacobsen, A.M.E.I.C., at the meeting of the Montreal Branch held on April 22nd. This paper was based on the construction of four churches, recently completed, in which all welded frames of rigid design were used, and included a description of the general construction and of the design and analysis of the steel frames. The author is on the staff of the Dominion Bridge Company Limited.

Gordon McL. Pitts, A.M.E.I.C., acted as chairman.

## Niagara Peninsula Branch

*P. A. Dewey, A.M.E.I.C., Secretary-Treasurer.*
*C. G. Moon, A.M.E.I.C., Branch News Editor.*

A joint meeting of the Branch with the Niagara Chemical and Industrial Association was held on March 18th, 1937, at the Hotel Leonard in St. Catharines.

Chairman George Wood A.M.E.I.C., presided and about seventy members assembled to hear Mr. Gordon McIntyre explain the process of refining gasoline.

Mr. McIntyre was introduced by Sydney Hairsine, A.M.E.I.C., as the chief chemist for the Imperial Oil at Sarnia. His talk was illustrated by lantern slides showing diagrammatic sections of the treating towers and processing machinery.

### Gasoline Refining

Most of the gasoline used in Canada and the United States as a motor fuel, explained Mr. McIntyre, is obtained from crude oil. It contains molecules of various sizes or properties and in the combining of these molecules rests the surety of a fuel which is adequate and economical for the modern automobile. As the car is improved so must the relative constituents of the fuel be varied and the two must progress simultaneously.

Quick starting, rapid acceleration and high compression call for an entirely different gasoline from that used in the earlier cars. Climatic variations also necessitate other changes in the molecular grading of the gasoline which is therefore regulated from time to time in the refinery.

By means of heat and pressure the crude oil is separated into the constituent parts containing roughly 20 per cent gasoline, 14 per cent kerosine, 24 per cent lubricating oil and the balance distillate, fuel oil and asphalt.

The "cracking coil" is the most important part in the process. Motor cars could not function properly without cracked gasoline which, combined with straight gasoline and absorption gasoline, produces the article of commercial use. Volatility and detonation are the important tests of a gasoline; the former being varied from as low as 5 lb. per. sq. in. for very hot climates, about 9 lb. for our temperate summer, to 10 or 12 lb. for winter use.

In replying to questions which were raised during a lengthy discussion, Mr. McIntyre made the following points.

Lubricating oil added to the gasoline is recommended, particularly for a new car. About ¼ per cent or a pint to 10 gallons of gasoline, does not change the octane value. A special "break-in" oil is also made to be used in the crank case.

The modern automobile engine has a thermal efficiency of some 25 per cent while the most efficient engines, those used in the Schneider cup races and burning a blend of gasoline, ethyl fluid, benzene and alcohol, attain 40 per cent efficiency.

Rapid acceleration, which is highly developed in the newer cars, is the principal cause of high fuel consumption.

Great Britain and Germany distil some of their gasoline from coal but this is not done in Canada.

A synthetic fuel of 100 octane value will increase the horse power of an engine 30 per cent or more, over a standard 87 octane gasoline, when used in a properly designed aircraft engine.

M. F. Ker, A.M.E.I.C., of Stamford, proposed the vote of thanks.

On April 15th, 1937 the Branch held an afternoon and evening meeting at Port Colbourne. Through the kindness of the International Nickel Company, members and their friends were shown something of the mysteries pertaining to refining.

The huge plant, with the recent extensions, was thrown open for inspection and qualified guides explained the various processes from the initial grinding and sulphide leaching to the electrolytic separation of the pure metal.

After a pause for refreshments at the well-appointed Company clubhouse, dinner was served in the new hall of the First Presbyterian Church.

Mr. Herbert Walter, manager of the refinery, spoke briefly after dinner and introduced Mr. F. L. LaQue, of the New York office, who then explained many of the properties and applications of nickel and the non-ferrous alloys.

The three principal sources of nickel are as follows: Copper-nickel bearing pyrohlite in which the chief nickel-bearing mineral is pentlandite. This is the most important source and is found chiefly in the Sudbury district, also to some extent in Norway; the Sudbury deposits comprising the largest known supplies of nickel in the world. These deposits are sufficient for possibly a hundred years at the present rate of consumption.

Silicates or oxidized ores in which garnierite is the principal nickel-bearing mineral; found in New Caledonia, an island in the Pacific ocean east of Australia and formerly a French penal colony.

The arsenical ores of nickel and cobalt, found in northern Ontario and, to some extent, on the continent in Saxony and elsewhere. A recent source for a small amount of Nickel is a by-product of the electrolytic copper refineries. Many copper ores carry minute quantities of nickel which accumulate in the electrolyte and have to be periodically removed; the nickel usually finding its way to the market as nickel salts used in electro-plating.

Mr. LaQue's talk on the non-ferrous metals was illustrated with slides and motion pictures depicting the development of the nickel industry. Several other films of local interest were also shown which filled in an enjoyable evening.

C. G. Cline, A.M.E.I.C., expressed the thanks of the meeting to the speaker, to Mr. Walter and to the International Nickel Company for their kindness and hospitality. Councillor E. P. Murphy, A.M.E.I.C., and Norman Geale, A.M.E.I.C., did the spade work for the meeting and are to be congratulated. An attendance of eighty-three made this one of the notable gatherings of a good season.

## Peterborough Branch

*W. T. Fanjoy, A.M.E.I.C., Secretary-Treasurer.*
*E. J. Davies, A.M.E.I.C., Branch News Editor.*

### Weather Forecasting

On March 11th, 1937, Dr. J. Patterson, Controller, Meteorological Service of Canada, addressed this Branch on the subject of weather forecasting. Dr. Patterson stated that despite frequent claims by amateur experimenters on behalf of methods of long range weather forecasting scientific meteorolgists are not yet able to forecast weather with any guarantee of accuracy more than twenty-four to thirty-six hours in advance. He held little hope for development of long range prediction in the near future.

At wide variance from the old amateur stand-bys of weather observation were the scientific methods of the present-day weatherman described by Dr. Patterson. It seemed that the scientific weatherman puts little stock in such household slogans as "Rain before seven, clear before eleven," and pays little attention to the thickness of rabbits' fur in the fall, or the matter of the bear seeing his shadow in the spring. The science of weather prediction has progressed in great strides in recent years.

The army general studying his outspread battlefield maps showing troop position and movements would feel almost at home in the modern meteorological headquarters, it appeared as Dr. Patterson described roughly the methods of prediction. Just as the military man anticipates likely results by observing the progress of various human forces on his maps, the weatherman predicts weather by observing the progress of elemental forces. By charting and graphing hundreds of thrice-daily reports from weather stations throughout the Dominion, meteorologists make for themselves a composite picture of the air mass movements under way in Canada.

Certainty of weather forecasting has been advanced in recent years through concentration on study of the movements of the dry, cold air masses from the polar areas and the warm, moist masses from the Tropical areas. Formerly, principal attention was paid not to the actual air movements but to air pressures at various points. Interpretation of air pressure data left too much to guesswork.

Dr. Patterson exhibited slides which traced the development of the meteorological science from 1872 to the present. The release of the balloons by means of which temperatures at heights from 10 to 20 miles are taken was depicted. Unexpectedly, the lowest stratosphere temperatures are encountered in the stratosphere over the equator and warmest stratosphere temperatures are encountered over the poles.

### Annual Students' and Juniors' Night

April 8th was the annual meeting which is in charge of students and juniors of this Branch and at which A. L. Malby, Jr.E.I.C., was chairman. Papers were given by four student members who are employed at the Canadian General Electric Company's Test Course.

W. Bergman, S.E.I.C., gave a talk on the "Features of the Petroleum Industry with special reference to the Turner Valley Oil Fields." Supporting his statement that the oil industry is a silent competitor of electricity he mentioned that in 1929 there were 450 men employed in the field of development and in 1937 there are over 900 thus employed. Mr. Bergman explained in detail the two general methods of sinking oil bore holes, i.e., the percussion method and the hydraulic rotary method. He also mentioned the fact that occasionally it was necessary to combine the two methods on the one hole as the nature of the substrata encountered varied from hard rock which requires the percussion method to sandy, soft soil which requires the rotary method.

E. L. Toy, S.E.I.C., gave a very interesting description of the "Sardine Industry," mentioning in particular the New Brunswick Sardine Plant. He explained the process from the catching of the small herring which are used for sardines, through the different operations of salting, flaking, drying, packing, oiling, cooking and packing for shipment. In this industry there is very little waste as the heads, tails and unsuitable herrings are used for fertilizer and the oil extracted from this waste is used for soap making. One point which is considered in the favour of Canadian sardines over European sardines is the fact that Canadian sardines are not smoked and are therefore considered more easily digested.

C. E. Lewis, S.E.I.C., gave a very thorough and informative paper on "Cylinder Wear in Gasoline Engines." Mr. Lewis stressed particularly the three main causes of cylinder wear, i.e., abrasion, erosion and corrosion, going into complete detail as to the action that occurs in each case with the consequent result. Mr. Lewis mentioned that the manufacturers are exerting every effort to incorporate features which will keep down or reduce cylinder wear and for the private owner he mentioned the following points:—

1. Use a good type of air cleaner and keep it clean.
2. Frequent changes of oil, using a good quality oil.
3. Keep the operating temperature of the engine well up, using a thermostat to control this.
4. Steady engine operation with proper gasoline mixture.

Mr. Lewis mentioned the fact that high engine speed did not necessarily cause cylinder wear, provided proper lubrication was available.

D. C. McCrady, S.E.I.C., discussed "Sanitary Analysis of Drinking Water." Mr. McCrady explained in detail the method of testing samples of drinking water for palatability and possible pollution. He went through the various steps as carried out in a modern laboratory to detect the possible presence of sewage particles in their chemical components. The most important part of this test was the personal inspection of the source of supply and its surroundings, as very frequently, although the water does not show any sign of pollution, the surroundings may be such that pollution may soon occur due to the breakdown of the soil through which the water filters to the well.

## Saskatchewan Branch

*J. J. White, M.E.I.C., Secretary-Treasurer.*
*R. J. Fyfe, A.M.E.I.C., Branch News Editor.*

### Annual Meeting

The annual meeting of the Saskatchewan Branch of The Institute was held in the LaSalle hotel, Regina, on April 2nd, 1937. Thirty-one members and friends were in attendance.

Stewart Young, M.E.I.C., the vice-chairman, conducted the business of the meeting. The speaker was Dr. J. W. Hedley, Regina, his subject being "Heredity and Environment." This subject, although greatly removed from any engineering activity, was very much appreciated by the members present, and a hearty vote of thanks was moved by Messrs. A. P. Linton, M.E.I.C., and H. C. Ritchie, M.E.I.C.

The election of officers of the Branch for the ensuing year resulted in Stewart Young, M.E.I.C., being elected chairman, with Messrs. R. W. Allen, M.E.I.C., H. S. Carpenter, M.E.I.C., and J. W. D. Farrell, M.E.I.C., being elected to the Executive committee.

## Vancouver Branch

*T. V. Berry, A.M.E.I.C., Secretary-Treasurer.*
*J. B. Barclay, A.M.E.I.C., Branch News Editor.*

At an evening meeting of the Vancouver Branch, on February, 26th, 1937. Mr. R. Weir, local manager of the Pressure Pipe Company of Canada, gave an address, illustrated with lantern slides, of the 14,000 ft. concrete pipe line installed at Capilano Canyon for Vancouver's water supply.

The pipe has an internal diameter of 63 in. with a head of water of water of 500 ft. giving a pressure of 218 lb. per sq. in.

The process of manufacture was to build a light cylindrical shell of No. 7 to No. 10. gauge steel. This was wrapped with a continuous steel spiral, kept 1 in. from the shell. An inner lining of reinforcing rods was then manufactured and inserted, special methods being adopted to keep the steel the necessary distance from the shell. This completed the fabrication of the reinforcing. The company's plant was equipped to rotate the pipe while in a horizontal position at a rapid speed, the inner concrete lining was then poured and spinning continued until the concrete was dense. Steam curing was then continued for four hours. The outer lining was then poured by setting the pipe in a vertical position and placing steel forms around it. Vibrators were used during the pouring. Steam curing was then continued for twenty hours.

Joints were made by welding a socket to the inner lining and the joints made on the field as in a socket and spiggot pipe, using oakum and lead. At each field joint the inner lining was plastered, and the outer by placing forms around the pipe and concreting.

This pipe has proved highly satisfactory, both during the laboratory tests for structural strength and leakage, and in the field for ease of erection and serviceability.

A vote of thanks was proposed by C. Brakenridge, M.E.I.C., for Mr. Weir's very interesting paper on this subject of manufacture of concrete pipes.

At the meeting of the Vancouver Branch of The Institute held on March 9th, Mr. A. G. Zima, research metallurgist of the International Nickel Company, gave an address illustrated with lantern slides, his subject being "The Role of Nickel in the Development of Cast Iron."

During the war, nickel was thought of only as a war-time material, and at the close of the war the price dropped to practically nothing. This caused the research department of International Nickel to try to find new uses for this metal, with the result that its uses in the field of armaments takes second place now. Cast iron, which was once replaced by cast steel, is now finding the uses of the former again relinquished to it.

Alloys of cast iron and nickel, with additions of chromium, copper, zinc, aluminum, etc, can be made to produce materials which have amazing properties. These alloys can be cast amazingly thin, they can be hardened to an unbelievable extent, they can be made non-corrosive, and if conditions warrant it, they can have a coefficient of expansion of zero. It is even possible to have a crucible product of cast iron which can be bent cold.

Ordinary cast iron contains particles of graphite throughout its mass. These particles are comparatively large, especially if the casting has cooled slowly, and these irregular pieces of graphite account for the weakness and non-uniformity of this material. The introduction of nickel acts as a graphitizer, that is, it causes the graphite to be distributed in very minute pieces uniformly so that they do not weaken the mass. At the same time the nickel toughens it and gives it uniform density and uniform strength. The nickel dissolves 100 per cent in the iron giving a tough material which can be machined. The further addition of chromium hardens the alloy and is especially useful where there is abrasive action. An alloy, for example, of 4½ per cent nickel with 1½ per cent chromium gives the toughest commercial cast iron alloy. In chill hardened cast iron, chromium acts as a chill deepener and nickel as a chill intensifier. This type of alloy with varying proportions of the nickel and chromium is largely used for dies in automobile manufacture for stamping fenders, and has three times the life of ordinary cast iron. It can be further heat treated thereby increasing the life another four times. This alloy is so strong that it has been used to replace manganese steel and effectively replaces the latter, except where there is excessive impact.

It is interesting to note that ordinary steel and alloys of steel have a modulus of elasticity of between 29 and 31 million, this modulus varies very slightly within these limits regardless of the steel alloy considered. Ordinary cast iron which has a modulus of from 8 to 12 million, can be made to have a modulus as high as 28 million with additions of nickel, chromium, and other elements. This increase in stiffness has made it possible to use cast iron in machine parts, such as paper mill rolls where stiffness is essential and if they were made of steel would be very costly.

Some of the uses for this new field of alloys are for rock crushers; pipes and tanks for chemical works, where the new Ni-resist has great non-corrosive properties; dies; grate bars, these are not subject to "grain growth" which was the disadvantage of using ordinary cast iron; abrasive surfaces; bearings, where the graphite in the iron acts as a natural lubrication, and many other places.

This address contained an unusual amount of information and Mr. Zima received a very sincere vote of thanks for his excellent paper.

The Vancouver Branch held its monthly dinner meeting on the evening of March 22nd, 1937. Twenty members sat down to dinner. After dinner the members were addressed by Mr. F. Vernon Jones, chief surveyor of the Fire Branch of the B.C. Underwriters Association.

Mr. Jones spoke on the subject "How Construction Affects Fire Insurance Rates." He discussed at length various factors in the construction of buildings and their relations to fire risks and insurance rates. Types of walls, floors, roofs, skylights, fire doors, openings in floors, window trim, etc, are all factors in fire hazard and the determination of fire rates. Other contributing factors influencing the rates are relative efficiencies of fire fighting systems, quantity and pressure of water available for fire fighting, proximity of other buildings, the nature of their construction and occupancy, nature of occupancy and nature of process hazards. All these factors have received a great amount of study and research and architects and engineers in designing structures should study these factors carefully in their design.

Following the address, a number of questions were answered by Mr. Jones.

Before adjournment the meeting was thrown open for a discussion on the proposed amendments to The Institute's by-laws.

## Winnipeg Branch

*H. L. Briggs, A.M.E.I.C., Secretary-Treasurer.*

THE BRITISH PROGRAMME OF PROTECTION AGAINST AERIAL GAS ATTACK

On March 25th, 1937, approximately one hundred and fifty members of the Winnipeg Branch and visitors heard Dr. F. W. White, of the faculty of medicine, University of Manitoba, deliver a paper on the above subject. Dr. White served for four years with the Royal Engineers.

One method of classifying gases is according to their effects. There are the lung irritants, such as chlorine, the sneezing gases, the tear gases, and the blister gases. The most powerful of the present day gases, mustard gas and lewisite, come within the last classification.

Three parts of lewisite mixed with 100,000,000 parts of air, make necessary the use of a gas mask. The blister gases attack all body surfaces, particularly if any perspiratory dampness is present. A complete outfit, consisting of respirator headpiece, oilskin clothing, and gum rubber boots, is necessary for complete protection.

Slides were shown of different types of gas masks which are being manufactured. An Air Raids Precautions Department has been operating for a year, and a large school has been established, giving instruction in the protection from gas. Householders are advised to make their cellars gasproof. Encouragement is being given to the construction of types of buildings which can readily be converted into first aid posts and decontamination centres.

The appreciation of those present was voiced to Dr. White by W. M. Scott, M.E.I.C.

An extended discussion took place on the consolidation by-law revisions, the ballots having been received shortly before the meeting.

Professor A. E. Macdonald, M.E.I.C., was chairman of the meeting.

THE TECHNIQUE OF MODERN FLYING

The address on April 1st by Flight-Lieutenant D. Edwards, of No. 12 Squadron, Royal Canadian Air Force, on the above subject, was received with much interest by sixty members and visitors present.

Flight-Lieutenant Edwards described how the horizon is used as the reference for level, and a distant cloud, a railway line, or some such feature as the reference for direction when an air pilot is flying by 'feel' or 'sense.' When scheduled flights must be made under practically all conditions of weather and light or darkness, these references are not available, moreover, the sense of balance of a human being when fast turns or banks are being made is not reliable.

Instrument flying is based primarily on the bank and turn indicator, while other instruments almost as indispensable are the air speed indicator, the altimeter, and the compass. The speaker clearly explained the comparative ease with which a pilot flying blind without the use of instruments could get into a spin.

The radio beam system as commonly used involves the directional transmission of short wave radio signals, the Morse signal for "a" (dot dash) being transmitted in two opposite quadrants, and the signal for "n" (dash dot) being transmitted in the other two quadrants. Neighbouring quadrants overlapped about three degrees, and any receiving set in this area when tuned in would pick up a continuous signal, which constitutes the so-called "beam." Every thirty seconds the "a" and "n" transmission is interrupted to give station identification.

The speaker was introduced by G. E. Cole, A.M.E.I.C., and the vote of thanks moved by D. A. Ross, M.E.I.C.

The chair was occupied by Professor A. E. Macdonald, M.E.I.C.

ELEVENTH ANNUAL SUPPER DANCE OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF MANITOBA, AND THE WINNIPEG BRANCH OF THE ENGINEERING INSTITUTE OF CANADA.

April 2nd, about 370 members of the two engineering bodies and their guests attended this habitually successful annual event, held in the main dining room of the Royal Alexandra hotel at Winnipeg. The arrangements were carried out by Mr. J. A. Meindl, with the assistance of a committee composed of Messrs. C. S. Landon, A. W. Smith, D. M. Stephens, A.M.E.I.C., and W. Youngman.

## List of New and Revised British Standards

(Issued during February and March, 1937)

B.S. No.

721—1937. *Machine Cut Gears. C. Worm Gearing.*
Applies to worm gearing comprising correctly generated worm wheels and profile-ground worms, connecting shafts at right angles, and having a normal pressure angle of worm thread of 20° of the following classes:—
Class A. Precision Gears for wheel pitch line speeds above 1000 feet per minute.
Class B. High Class Gears for wheel pitch line speeds below 1500 feet per minute.
Class C. Commercial Gears for wheel pitch line speeds below 300 feet per minute.

727—1937. *Standard Method for the Characteristics and Performance of Apparatus for the Measurement of Radio Interference.*
This Standard defines the characteristics and performance of apparatus suitable for the measurement of radio interference, these characteristics having been internationally agreed. Also, describes in detail the design of an instrument complying with the Standard as developed by the General Post Office.

Copies of the new specifications may be obtained from the Publications Department, British Standards Institution, 28, Victoria Street, London, S.W.1., and from the Canadian Engineering Standards Association, 79, Sussex Street, Ottawa.

# Preliminary Notice

## of Applications for Admission and for Transfer

April 30th, 1937

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

The Council will consider the applications herein described in June, 1937.

R. J. Durley, Secretary.

*The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years inthe case of a candid ate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of,age, and shall have been engaged in some branch of engineering for at least six years which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch ofengineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more year.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard.

**A Student** beshallat least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.

### FOR ADMISSION

ALLEN—ARCHIE MENZO, of Edmonton, Alta., Born at Cameron, N.Y., July 17th, 1883; Educ., Private study; 1901-04, lineman and inspr., Century Telephone Constrn. Co.; 1909-10, inspr. and combination man, N.W. Telephone and Telegraph Co.; 1910 to date, with the Alberta Government Telephones, Edmonton, Alta., as follows: 1910-13, inspr., dist. foreman, and chief inspr.; 1914-19, local agent and wire chief; 1920-29, plant chief; 1929 to date, constrn. engr.
References: J. D. Baker, C. E. Garnett, H. J. McLean, H. B. LeBourveau, G. H. Thompson, J. Dow.

ASTELS—FLETCHER, of 474 Cooper St., Ottawa, Ont., Born at New Carlisle, Que., June 17th, 1888; Educ., B.S. (Elec. and Civil), Tri-State College, Angola, Indiana, 1924; 1919, dftsman., Canadian Ingersoll Rand; 1920-21, dftsman., City of Sherbrooke, Que.; 1924 to 1936, with the Foundation Co. of Canada Ltd., as follows: instr'man., Survey peribonka; res. engr. on the following—Marconi trans. tower foundations; Chateau Laurier; St. Lawrence Paper Mill, Three Rivers; James Maclaren paper mill, Masson, Que.; Postal Terminal foundations, Ottawa; field engr. on the following—Hemming Falls power development; paper mill, Port Alfred, Que.; MacLaren power development, Masson, Que.; Caughnawaga bridge piers, Montreal; Orleans bridge piers, Quebec; Saint John Harbour.
References: H. V. Serson, E. Viens, N. B. MacRostie, A. T. Hurter, W. Griesbach, L. C. Jacobs, J. H. McKinney.

BUTLER—ERNEST, of 530 St. Francois Xavier St., Three Rivers, Que., Born at Manchester, England, Feb. 13th, 1889; Educ., 1905-09, Institute of Technology, Manchester; 1905-08, dftsman., steamfittings and appliances, Holden & Brook Ltd., Manchester; 1908-09, mech. equipment, telephone exch. equipment, General Electric Co. Ltd., Manchester; 1909-10, designer, pumping equipment, tank work, J. McDougall, Co., Montreal; 1910-12, designer i/c refrigerator car work, C.P.R. Angus shops; 1912-18, designer on telephone exch. equipment, gen. power station work, also ab. work, Northern Electric Co. Ltd., Montreal; 1918-23, asst. chief designer on design and layout of paper mill equipment, mill extensions, etc., Laurentide Co. Ltd., Grand'Mere, Que.; 1923-25, designer on paper machy. and equipment, Charles Walmsley & Co. Ltd., Longueuil, Que.; 1925-30, chief designer and estimator on paper mill equipment, mill extensions and mtce., St. Maurice Paper Co. Ltd., Cap de la Madeleine, Que.; 1930 to date, chief designer and estimator on paper mill equipment, mill extensions and mtce., Wayagamack Divn., Consolidated Paper Corporation, Three Rivers, Que.
References: E. B. Wardle, H. O. Keay, F. W. Bradshaw, C. H. Jette, J. T. Lakin.

CHAREST—PIERRE ANTOINE, of Edmundston, N.B., Born at Val Brillant, Que., Feb. 11th, 1913; Educ., High School Leaving Cert., Edmundston, N.B., 1930. I.C.S. Diploma in Mech. Engrg.; 1931-33, tester, technical control, pulp mill, and 1934 to date, dftsman., pulp and paper mill, Fraser Companies Ltd., Edmundston, N.B.
References: F. O. White, J. E. Cade, H. A. Thompson, W. A. Ketchen, J. F. Mackenzie.

COLPITTS—CECIL ASHTON, of Calgary, Alta., Born at Winnipeg, Man., Jan. 23rd, 1907; Educ., B.Sc. (C.E.), Univ. of Man., 1933; 1926-28, chainman, rodman, material checker, C.P.R., North Battleford; 1928-32 (summers), instr'man., and 1934 to date, transitman, operating dept., C.P.R., Calgary, Alta.
References: R. C. Harris, T. Lees, J. N. Finlayson, A. E. Sharpe, G. H. Herriot.

EVANS—BEVERLEY ABBOTT, of 1333 Elliot St., Saskatoon, Sask., Born at Kingsey, Que., Jan. 14th, 1903; Educ., B.Sc. (Civil), 1930, M.Sc. (Civil), Univ. of Sask., 1936; 1928 (summer), survey work; 1929 (summer), constrn. work on power house in Saskatoon; 1930-31, constrn. work, engrg. dept., City of Saskatoon, instrument work and inspection; 1931-33, designing engr., on Broadway Bridge, Saskatoon; 1935, designing engr., and Aug. 1935 to date, res. engr. on Ceepee Bridge, Saskatchewan, for Dept. Public Works of Canada.
References: C. J. Mackenzie, I. M. Fraser, W. E. Lovell, R. A. Spencer, E. K. Phillips, F. G. Goodspeed.

HARLING—FRANK NORMAN, of 60 Chesterfield Ave., Westmount, Que., Born at Westmount, Nov. 1st, 1900; Educ., B.Sc. (Civil), McGill Univ., 1923; 1920 (summer), inspection, concrete work, Ballantyne Pier, Vancouver; 1922 (summer), mining surveys, Northern Ontario and Quebec; 1923-24, instr'man., and inspr. on grain elevator constrn for J. S. Metcalf Co. Ltd., Vancouver; 1924-25, res. engr. for Vickers Limited, London, on grain elevator and pier constrn. at Vancouver, also part time with the Vancouver Harbour Board on dredging; 1926-28, dftsman. and designer, Power Engineering Company, Montreal, during constrn. on Gatineau power plants; 1928-29, asst office mgr., Thos. Harling & Son Ltd., steamship agents, Montreal; 1929-35, with W. B. McLean, M.E.I.C., as asst. engr., designing and installing grain handling equipment, acted as supt. during constrn. of large contracts at Montreal, Sorel and Saint John, N.B.; 1935, engrg. staff of Aluminum Co. of Canada, during constrn. of ore plant extension at Arvida, i/c of mech. equipment and piping drawings; Jan. 1936 to date, engr. with Canadian Industries Limited, Montreal, at present in charge of all equipment layout and detail drawings for large proposed plant.
References: E. H. James, J. A. McCrory, W. B. McLean, I. R. Tait, J. H. Hunter, L. Coke-Hill, A. B. McEwen, C. D. Woolward.

HENSON—GEORGE STANLEY GORDON, of 1067 Ingersoll St., Winnipeg, Man., Born at Winnipeg, June 12th, 1912; Educ., B.Sc. (E.E.), Univ. of Man., 1935; 1928-32 (summers), with Canadian Engineering and Construction Co.; At present, dftsman., Winnipeg Electric Company, Winnipeg, Man.
References: E. V. Caton, L. M. Hovey, F. F. Griffin, C. P. Haltalin, E. P. Fetherstonhaugh.

LEFRANCOIS—J. GERMAIN, of 123 Chemin Chambly, Longueuil, Que., Born at St. Felix de Valois, Que., Aug. 8th, 1909; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1936; 1935 (summer), asst. engr., Dept. of Highways, Prov. of Quebec; June 1936 to date, sales engr., oil burner and stoker dept., Canadian Fairbanks Morse Co. Ltd., Montreal, Que.
References: A. Mailhiot, A. Frigon, A. Vincent, J. A. Lalonde, M. Gerin, A. Cousineau.

MENARD—JOSEPH RAYMOND, of Quebec, Que., Born at Three Rivers, Que., June 28th, 1909; Educ., 1924-26, St. Dunstan's Univ., P.E.I., I.C.S., Civil Engrg Course, 1932. Private course in Calculus, 1927-28-29; With the C.N.R. as follows: 1925-26-27 (summers), chainman on track centering and grades; 1927-28, rodman on constrn., St. Felicien-Dolbeau; 1928-29, rodman on mtce.; 1929-31, instr'man., track centering, grades, yard surveys, pile driving, culvert constrn., bridge constrn., etc.; 1931-34, associate with A. E. Bourbeau, C.E., surveying, constrn., etc., St. Hyacinthe, Que.; 1936 (June-Nov.), asst. chief of party, location of Senneterre-Rouyn branch line, C.N.R.; At present res. engr., C.N.R., Malartic, via Amos, Que.
References: R. A. Baldwin, A. Tremblay, T. J. F. King, S. J. H. Waller, L. C. Dupuis, T. T. Irving, C. S. Gzowski.

MOLLER—HOLGER PETER, of Dolbeau, Que., Born at New York, N.Y., June 9th, 1893; Educ., B.Sc., in Elec. Engrg., Royal Technical College, Copenhagen, 1923; 1923-24, sales engr. for various Danish firms; 1926-27, dftsman., St. Maurice Valley Corpn. Ltd.; 1927-28, dftsman., 1928-29, foreman, elect'l. dept., i/c mtce and operating crews, and from 1929 to date, elect'l. supt., Lake St. John Power & Paper Co. Ltd., Dolbeau, Que.

References: C. M. Bang, D. A. Evans, A. G. Jacques, E. Cowan, F. L. Lawton, S. J. Fisher.

ORLANDO—EDWARD EUGENE, of Montreal, Que., Born at St. Margaret's Bay, N.S., Feb. 1st, 1905; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1927; with the Canadian Westinghouse Co., as follows: 1927-28, student course; 1928-31, dfting. and engrg. on switching equipment; 1931-34, specifications and estimating on switching equipment, meters, relays and industrial control; 1934 to date, sales engrg., Montreal Branch.

References: W. F. McLaren, J. R. Dunbar, J. Palmer, H. H. Bell, A. D. Ross, H. A. Ricker, G. W. Arnold.

PARE—A. EUCLIDE, of Quebec, Que., Born at Lawrence, Mass., Jan. 9th, 1903; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1931; R.P.E., of Que.; 1929-30 (summers), transitman, etc., on topog'l. surveys; June 1931 design and supervision of concrete constrn. work for Z. Langlais, A.M.E.I.C., Quebec; 1931-33, technical service, City of Montreal surveys, design and supervision of pavings, constrn. of sewers, etc.; 1933-34, asst. to chief of party and transitman for survey and study of hydro-electric project on Rimouski River, Quebec Streams Commn.; 1934-36, asst. engr., Dept. of Public Works Canada, at Rimouski office, design, supervision and i/c of work pertaining to wharves, dredging, steel sheet piling, concrete, cribwork, surveys, etc.; April 1936 to date, hydraulic service, Prov. of Quebec, approbation of plans and specifications for dams, study of hydroelectric projects and contracts, inspection and gen. office work pertaining to Water Course Act.

References: A. B. Normandin, O. O. Lefebvre, A. Mailhiot, J. G. Caron, L. Martin, E. Laurence.

PETERSON—ALFRED, of Iroquois Falls, Ont., Born at Montreal, Que., May 26th, 1913; Educ., B.Eng., McGill Univ., 1934; June 1935 to date, instrument engr., Abitibi Power and Paper Co., Iroquois Falls, Ont.

References: E. Brown, R. DeL. French, C. M. McKergow, J. B. Phillips, L. R. McCurdy, J. F. Plow, G. A. Wallace.

ROLPH—FRANK BERNARD, of Lachine, Que., Born at Westmount, Que., July 26th, 1906; Educ., Grad., R.M.C., 1927; B.Sc. (Civil), McGill Univ., 1928; with the John S. Metcalf Co. Ltd., as follows: 1927, inspection of bldg. of grain elevator at Port McNichol; 1928-29, inspection on pile driving of grain elevator for Saint John Harbour Commissioners; 1929-30, res. engr. superv sing constrn. of grain gallery; 1930-31, constrn. of foundations, Saint John; 1931, supervising constrn. of grain elevator, Canada Malting Co., Montreal; 1931-32, supervising engr. on grain galleries constrn. and structural steel sheds for Saint John Harbour reconstrn.; 1932-33, supt. of machy. installn. Saint John Harbour Commn. elevator and grain gallery system; 1933-37, various inspection work, also some design and estimating, including supt. on grain gallery constrn. and machy. installn. at Halifax, N.S. At present, engr. in charge of field constrn.

References: L. Coke-Hill, A. Gray, V. S. Chesnut, C. S. Bennett, E. H. James, J. B. Stirling, H. Rolph, J. H. McKinney.

SANNE—EINAR TRYGUE, of 5770 Hutchison St., Montreal, Que., Born at Oslo, Norway, Mar. 19th, 1878; Educ., 1897-1898, Tech. Evening School, Providence, R.I. 1898-1901, R.I. School of Design (evenings), I.C.S., Mech. Engrg.; 1895-99, ap'tice machinist, Mosburg & Graneville Mfg. Co., Providence, R.I.; 1899-1900, machinist, 1900-04, dftsman., Rhode Island Locomotive Works, Providence; 1904-06, leading dftsman., Louisville & Nashville R.R.; with the Montreal Locomotive Works Ltd., as follows: 1906-12, leading dftsman., 1912-15, asst. chief dftsman., 1915-18, i/c engrg. dept., designing tools and equipment for munitions manufacture, 1918 to date, i/c engrg. dept., detail design of Welland Canal machy. (gen. design by Candn. Govt. engineers), ordering of materials for above; i/c of new locomotive designs from 1918 to date including new streamlined locomotives for Canadian rlys., including detail design and responsibility for drawings, weight distribution, etc.

References: S. J. Hungerford, W. F. Drysdale, H. B. Bowen, W. A. Newman, H. H. Vaughan, H. D. Cameron, F. Williams.

STALKER—ANDREW DOUGLAS, of 67 Aylmer Ave., Ottawa, Ont., Born at Ottawa, Nov. 30th, 1892; Educ., 1914-15, completed 1st year Faculty of Applied Science, 1915-16, attended special classes, Queen's University; 1911-13, dftsman., leveller and instrumentman, engrg. dept., City of Ottawa; 1913-16, i/c of pitometer survey of Ottawa Water Distribution System (except during college terms); 1916-19, Works Officer, 38th Bn. Canadian Infantry; 1919-28, supervision of constrn. in Ottawa Water Dept., including in addition to routine work—51" overland pipe extension, distribution system, Eastview, low lift pumping station, Lemieux Island; 1929-32, res. engr. on constrn. of Ottawa water purification plant and pumping station extension, including installn. of pumps and equipment; 1933 to date, asst. city water works engr., Ottawa, Ont.; designed and supervised the following works: 11,000 volt transmission line from Val Tetreau to Lemieux Island; reconditioning Queen St. Pumping Station, incl. installn. of 17 M.G.D. hydraulic turbine driven high lift pumping unit; installn. of electrically driven high lift pumping machy. at Lemieux Island pumping station; steel pony truss pipe carrying bridge over the channel of the Ottawa River between Lemieux Island and the Ontario mainland, and installn. of 48" diam. pipe line from Lemieux Island water purification plant to point on Ontario mainland.

References: W. E. MacDonald, F. C. Askwith, W. Storrie, C. P. Edwards, A. K. Hay, N. B. MacRostie.

TAYLOR—THOMAS ALLISTAIR IAN CLARK, of Arvida, Que., Born at Edmonton, Alta., Sept. 16th, 1912; Educ., B.Sc. (E.E.), Univ. of Alta., 1936; 1936 (Sept.-Dec.), chainman, C.N.R.; Dec. 1936 to date, junior engr., Saguenay Power Co. Ltd., Arvida, Que.

References: F. L. Lawton, R. W. Ross, W. E. Cornish, R. S. L. Wilson, C. Miller.

WANGEL—REINHOLD, of 1193 Mackay St., Montreal, Que., Born at Ruovesi, Finland, May 1st, 1893; Educ., Civil Engr., Technical University of Finland, 1919; 1913-14-15 (summers), Govt. rlys., road and waterway depts; 1918-19, engrg. dept., Helsingfors, i/c street and waterwork dept.; 1919-20, Granot Ltd., i/c road constrn. and surveying in St. Andre—Ladoga district; 1920-21, computer and dftsman., General Engineering Co. Ltd., Helsingfors; 1921-22, computer and dftsman. for Dr. Engineer Adolf Ludin, Karlsruhe, Germany, water projects, high pressure plants; 1922-24, computer and dftsman., General Engineering Co. Ltd., Helsingfors; 1924 (May-Dec.), city engr. and supt. of electric power house, Town of Lappenranta, Finland; 1925-29, Aluminum Co. of Canada, Arvida, Que., struct'l. design, gen. engrg. dfting., city layouts, topog'l. work, mech. dfting.; 1929-31, computer and dftsman. for F. B. Brown, M.E.I.C., Montreal; 1931-35, contracting in Montreal, constrn. of bungalows, log houses, alterations and repairs; 1935 to date, with Warden King Ltd., Montreal, mech'l. engrg., heating system and layouts, design and development of boilers, radiators, etc., air conditions, calculating and design. May 1937 to date, i/c of heating dept.

References: H. R. Wake, S. S. Colle, P. G. Gauthier, B K. Boulton, T. M. Moran.

### FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

BUCHANAN—COLIN ARCHIBALD, of Portneuf, Que., Born at Levis, Que., Sept. 14th, 1889; Educ., B.Sc. (Civil), McGill Univ., 1919; 1907-14, engrg. staff, N.T.C. Rly.; 1915-16, C.E.F. (Engineers); 1916, Lauzon Drydock; 1916-18, engrg. staff, Quebec and Saguenay Rly.; 1919-20, chief engr., Jos. Gosselin Ltd.; 1921-23, private practice; 1920-21, constrn. supt., Wayagamack Pulp & Paper Co.; 1923-24, designer, and 1924 to date, chief engr., i/c engrg. dept., Donnacona Paper Co. Ltd., Portneuf. Que. (*A.M. 1919.*)

References. A. R. Decary, E. Brown, A. A. MacDiarmid, A. Ferguson, J. O'Halloran.

PEARSON—VERNON, of 9908-90th Avenue, Edmonton, Alta., Born at Rye, Sussex, England, April 1st, 1889; Educ., Brassey Institute, Hastings, 1904-09; 1904-09, ap'ticeship, Corpn. of Hastings; 1909-10, Sevenoaks Iron Works; 1910-14, Lethbridge Iron Works; 1914-19, with the Canmore Coal Company, first in charge of electrification, and later asst. chief engr. and chief engr.; 1919-23, supt. of public utilities, Town of MacLeod; 1923-28, mech'l. supt., Govt. of Alta.; 1928-31, mgr., Electrical Engineers Ltd.; Edmonton, Alta.; 1931-34, owner, Vernon Pearson Co., electrical engineers; 1934-37, chief engr. and bldg. supt., Royal Alexandra Hospital, Edmonton; at present, mech'l. supt., Govt. of Alberta. In charge of all govt. power plants, and the administration of the Steam Boiler and Factory Acts. (*A.M. 1926.*)

References: H. P. Keith, C. Garnett, R. J. Gibb, A. W. Haddow, R. M. Dingwall.

### FOR TRANSFER FROM THE CLASS OF JUNIOR

DE JONG—SYBREN HENRY, of Ottawa, Ont., Born at East Kildonan, Man., Oct. 20th, 1908; Educ., B.Sc. (C.E.), Univ. of Man., 1931. Advanced theory of structures (Major), Business Economics (Minor) completed towards M.Sc. (Thesis to be written); 1931-32, 1932-33, 1934-35, demonstrator, Univ. of Man.; with the Manitoba Good Roads Board as follows: 1927-28 (summers), rodman; 1929-1930, 1935 (summers), instr'man.; 1931 (June-Sept.), oil inspr.; 1935 (Apr.-Sept.), dftsman. and office mgr., Fort Garry Motor Body & Paint Works Ltd., Winnipeg; 1936 (Feb.-Apr.), night school instructor, City of Winnipeg School Board and Dept. of Education, Manitoba; at present, compiler, Dept. of Mines and Resources, Topographic and Air Surveys Branch, Dominion Government. (*Jr. 1936.*)

References: J. N. Finlayson, A. J. Taunton, G. H. Herriot, A. E. Macdonald, E. M. Dennis, F. J. Cunningham, T. C. Main.

HARDY—ROBERT McDONALD, of Edmonton, Alta., Born at Winnipeg, Man., Sept 25th, 1906; Educ., B.Sc., Univ. of Man., 1929; M.Sc., McGill Univ., 1930; R.P.E. of Alta.; D.L.S., A.L.S., S.L.S.; 1927 (summer), dftsman., Dominion Bridge Co., Winnipeg; 1928-29-30 (summers), designer and dftsman., Truscon Steel Co., Winnipeg; 1931 (4 mos.), designer and dftsman., City of Edmonton; 1932 (6 mos), general surveys; 1935-36 (summers), professional surveying practice; 1930 to date, lecturer in civil engrg., University of Alberta, Edmonton, Alta. (*St. 1928, Jr. 1934.*)

References: R. S. L. Wilson, A. Campbell, H. L. Seymour, J. N. Finlayson, H. R. Webb.

McCORMACK—DONALD NEILL, of Kapuskasing, Ont., Born at Fredericton, N.B., Feb. 16th, 1905; Educ., B.Sc. (E.E.), 1928, B.Sc. (C.E.), 1933, Univ. of N.B.; 1925 (summer), field dftsman., N.B. Electric Power Commn.; 1926-27 (summers), asst. to city engr., Fredericton, N.B.; 1928-29, engr., Canadian Dexter P. Cooper Co., Campobello, N.B., on Passamaquoddy power development; 1929-30, engr., Price Bros. & Co. Ltd., Quebec; 1930-31, i/c of finishing and shipping room and of records, Donnacona Board Mill, Donnacona, Que.; 1931-32, asst. to res. engr., highway divn., Dept. of Public Works of N.B.; 1932-34, misc. engrg. work; May 1934 to date, engr., Spruce Falls Power & Paper Co. Ltd., Kapuskasing, Ont. (*St. 1921, Jr. 1928.*)

References: D. J. Emrey, G. S. Clark, C. W. Boast, C. R. Murdock, E. O. Turner, W. J. Lawson.

NEIL—JOHN STUART, of Calgary, Alta., Born at Gourock, Renfrewshire, Scotland, Feb. 1st, 1907; Educ., B.Sc. (C.E.), Univ. of Alta., 1930; 1924-25, rodman, 1926-27, instr'man., C.P.R.; 1928-31, with Truscon Steel Company of Canada, reinforced concrete design and detailing; 1931-32, City of Calgary, engrg. dept., design and dfting. on new sewage disposal plant, also inspr. of constrn. on same plant; 1934-35, supt. of constrn. for the Coulson Construction Co. on a reinforced concrete garage, showrooms, offices and service station for the Texas Co. of Canada and the Ford Motor Co., at Saskatoon, Sask. Also design of roof trusses and reinforced concrete for this bldg.; 1935 to date, test engr., Canadian Western Natural Gas, Light, Heat and Power Co., including combustion and efficiency tests on gas fired industrial boilers and domestic appliances, also estimates of heat and load requirements and design of heating and air conditioning installns. (*Jr. 1932.*)

References: J. R. Wood, F. J. Heuperman, R. S. L. Wilson, H. R. Webb, E. W. Bowness.

WILLIAMS—RICHARD LOUIS, of 159-24th Ave., Lachine, Que., Born at Redcar, Yorks, England, Nov. 6th, 1902; Educ., B.Sc. (Mech.), McGill Univ., 1931; with the Dominion Bridge Company, Ltd., Lachine, as follows: 1918-23, machinist ap'tice; 1923-26 and summers 1927-1928, 1930, dftsman; 1931-32, inspr. and time study observer; 1935 to date, designer and estimator. (*St. 1930, Jr. 1933.*)

References: F. Newell, R. H. Findlay, R. S. Eadie, F. P. Shearwood, E. Brown, C. O. Maddock, A. H. Munson, A. Peden.

### FOR TRANSFER FROM THE CLASS OF STUDENT

LILLEY—LEDFORD GEORGE, of 57 Havelock St., West Saint John, N.B., Born at West Saint John, June 11th, 1913; Educ., B.Sc. (E.E.), Univ. of N.B., 1935; 1935-36, dftsman., 1936-37, inspr. of constrn. on reconstrn. of wharves at Saint John, National Harbour Board; at present, dftsman., Dept. of Public Works of Canada, Saint John, N.B. (*St. 1935.*)

References: F. C. Jewett, V. S. Chesnut, G. Stead, J. R. Freeman, G. H. Thurber.

MATHIESON—JOHN RICHARD, of Port Arthur, Ont., Born at Winnipeg, Man., June 26th, 1909; Educ., B.Sc. (C.E.), Univ. of Man., 1936; 1927-29, chainman, rodman, C.P.R. constrn. dept.; 1929-31, instr'man., C.P.R.; 1936 to date, designer dftsman., C. D. Howe Co. Ltd., Port Arthur, Ont. (*St. 1935.*)

References: B. L. Reid, E. A. Kelly, T. F. Francis, A. E. Macdonald, J. M. Fleming.

PASK—ARTHUR HENRY, of Drummondville, Que., Born at Zeneta, Sask., July 2nd, 1911; Educ., B.Sc. (E.E.), Univ. of Man., 1935; 1936 (2 mos.), dfting and assimilation of paper mill operational data, Howard Smith Paper Mills; 1936-37, dftsman., pump and Diesel engine installns., Canadian Fairbanks Morse Co. Ltd.; at present, asst. plant engr., Eagle Pencil Co., Drummondville, Que. (*St. 1935.*)

References: M. Gerin, W. G. Scott, J. F. Plow, N. M. Hall, E. P. Fetherstonhaugh.

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STEAM AND MECHANICAL ENGINEER. Married. Wants position with industrial company within 100 mile radius of Montreal. Would prefer position in charge of maintenance. Can undertake plant layout work, handling steam lines, look after alterations or extensions, make installations on construction work. Previously in charge of similar work and can prepare own drawings. Have good all round knowledge of all trades. 35 years experience. Apply to Box No. 441-W.

DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aero-photographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.

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ELECTRICAL AND CIVIL ENGINEER, B.Sc. Elec. '29, B.Sc. Civil '33. Jr.E.I.C. Age 29. Experience includes four months with Can. Gen. Elec. Co., approximately three years in engineering office of large electrical manufacturing company in Montreal, the last six months of which was spent as commercial engineer. For the last year and a half employed in electrical repair shop. Best of references. Apply to Box No. 693-W.

YOUNG CIVIL ENGINEER, B.Sc. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

MECHANICAL ENGINEER, S.E.I.C., B.A.Sc., Univ. of B.C. '30. Single, age 24. Sixteen months with the Allis-Chalmers Mfg. Co. as student engineer. Experience includes foundry production, erection and operation of steam turbines, erection of hydraulic machinery, and testing texropes and centrifugal pumps. Location immaterial. Available at once. Apply to Box No. 735-W.

## Situations Wanted

CIVIL ENGINEER, B.Sc., M.Sc., R.P.E.; Lieut. C.E., R.O. 16 years municipal, highway and construction, 5 years overseas. Married. Read, write and talk French. Will go anywhere. Apply to Box No. 737-W.

RADIO AND ELECTRICAL ENGINEER, B.Sc., '31, Jr.E.I.C. Single. Age 29. One year and a half actual field experience in power and lighting equipment. Extensive work in telephone and radio layouts in switchboard and installation depts. Particularly interested and experienced in sales and traffic work in telephone and radio company. At present supervisor over sales and service of radio and electrical company. Available on short notice. Location immaterial. Apply to Box No. 740-W.

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CIVIL ENGINEER, S.E.I.C., B.Sc. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman, compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

STRUCTURAL ENGINEER, B.A.Sc., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

CIVIL ENGINEER, B.A.Sc., Jr.E.I.C., age 32, married. Two years in pulp mills draughting and designing additions, maintenance and plant layout. Three and a half years in the Toronto Building Department, checking and designing for steel, reinforced concrete and ordinary structures. One and a half years as transitman and draughtsman on road location and maintenance work. Available at once. Location immaterial. Apply to Box No. 899-W.

CIVIL ENGINEER, B.A.Sc. (Univ. of Toronto '27). Age 34. Familiar with house building cost, experience combines structural engineering, construction and house building and improvement, interested in obtaining a connection with firms investigating housing problems, making building loans or with a company engaged in construction or building costs. Apply to Box No. 910-W.

CIVIL ENGINEER, B.Sc., O.P.E. Experience includes several years on municipal work-design and construction of sewers, steel and concrete bridges, watermains and pavements. Available at once. Apply to Box No. 950-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.

## Situations Wanted

ELECTRICAL ENGINEER AND GEOPHYSICIST. B.Sc. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No. 1168-W.

ELECTRICAL ENGINEER, B.Sc. '34 (Univ. of N.B.), S.E.I.C. Age 21, single. Desires any kind of electrical work. Will consider any location. Apply to Box No. 1262-W.

CIVIL ENGINEER, M.E.I.C. Married. Age 38. Twenty years experience in organization, design and estimating, and cost accounting. Active service in France. Apply to Box No. 1367-W.

ENGINEER SUPERINTENDENT, A.M.E.I.C., R.P.E., Que. and Alta. Age 47. Married. Twenty years experience as engineer and superintendent in charge of hydro-electric, industrial, railroad, and irrigation construction. Specialized in rock excavation and suction dredging. Intimate knowledge of costs, estimating and organizing. Available immediately. Apply to Box No. 1411-W.

CIVIL AND ELECTRICAL ENGINEER, Univ. of Man. '35 and '36. S.E.I.C. Experience in irrigation and mapping. Available at once. Location immaterial. Box No. 1418-W.

CIVIL ENGINEER, B.Sc. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

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ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.Sc. '31 (Univ. of Alta.), Jr.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work, location immaterial and available at once. Apply to Box No. 1522-W.

CIVIL ENGINEER, B.Sc. '32, S.E.I.C., P.E.N.B., Dy.L.S.N.B., age 32. Experience in mining, both coal and metals, private and legal surveys, railroad construction, geology and building construction. At present in private practice in coal mining district. Desirous of changing location for position either in mining field or construction in Canada. or abroad. Apply to Box No. 1562-W.

RESIDENT ENGINEER, familiar with all types of surveys and construction work including, railway, roads, irrigation, drainage, buildings and air ports. Executive ability. Had charge of several large projects. Intimate knowledge of reports and estimates. Available immediately. Any location. Apply to Box No. 1567-W.

CIVIL ENGINEER, B.Sc. '17, O.P.E. Married. Executive and administrative experience. Extensive office and field experience in harbour works, dredging; both steam and electric railways in location, construction and maintenance; telephone works in design, construction and maintenance of pole lines, wire, cable and conduit; highways in location, construction and paving; municipal works in roads, sidewalks, sewers and water mains. Intimate knowledge of estimating, unit costs, cost accounting and analysis. Some knowledge of air conditioning. Willing to locate anywhere. Available at once. Apply to Box No. 1587-W.

ELECTRICAL ENGINEER, B.Sc. '27 (McGill), A.M.E.I.C. Age 36. Married. Bilingual. Three years experience in telephone work (installation of manual and automatic exchanges). One year electrical prospecting. Nine years experience with electrical power company. Apply to Box No. 1601-W.

SEMICENTENNIAL NUMBER

# THE ENGINEERING JOURNAL

THE JOURNAL OF THE ENGINEERING INSTITUTE OF CANADA

JUNE, 1937 VOLUME XX, No. 6

## *Contents*



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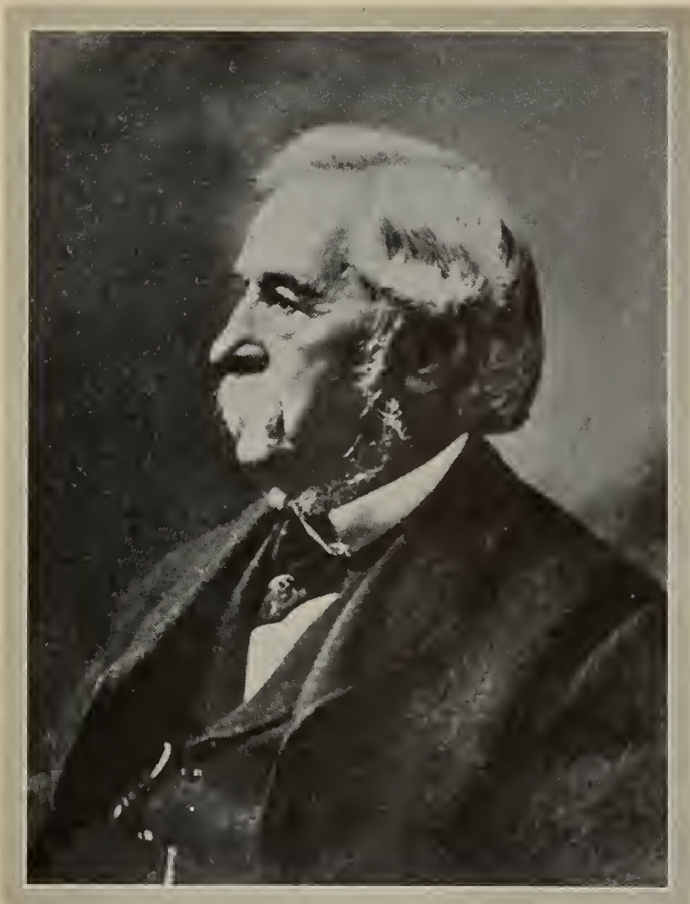
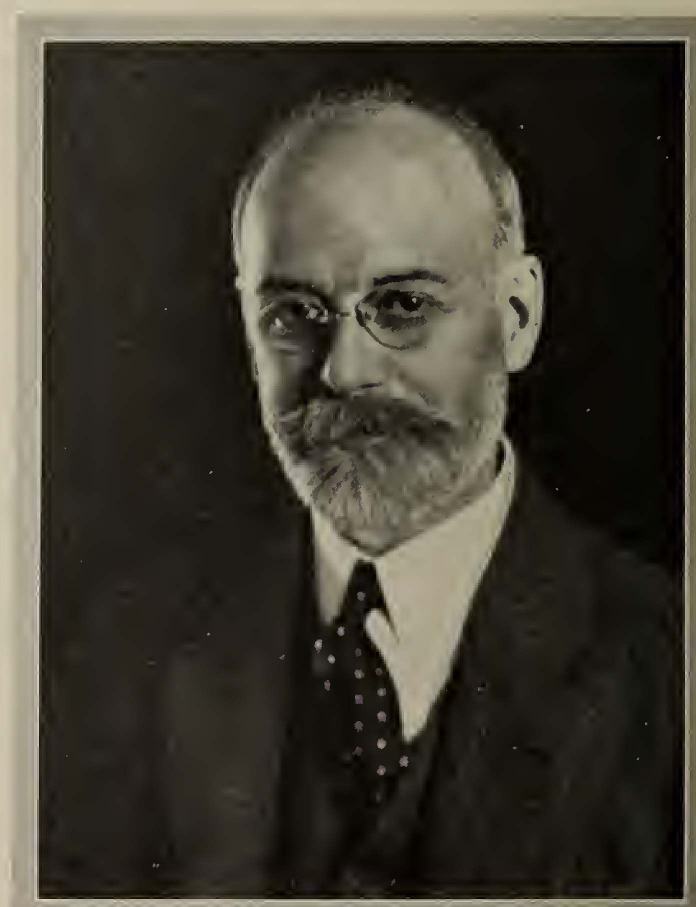


THOMAS COLTRIN KEEFER
President, 1887



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President, 1937

# Foreword by the President

In writing the life of an eminent Canadian engineer, a boy from a Scottish country school who became chief engineer of two great Canadian railways and Chancellor of a great university, his biographer began with these words:

> "How often has it been said that while the engineer as a technologist may be capable, he is not usually a citizen in the enlarged sense of the word! His structures may be safe; his work may display an ingenuity that compels admiration; his integrity may be above question, but outside of his professional work his influence is not felt. Those engineers who have received recognition are the exceptions, and they have won it largely through widening their contact with the pulsating life of their time."

In this paragraph Peter Gillespie pointed directly to the main reason for the formation of such societies as The Engineering Institute of Canada, whose Semicentennial we are celebrating this month. To do his best work the engineer must not lead a cloistered life apart from his fellow workers and unrecognized by the public. He needs to exchange professional information and experience with others who belong to the "calling of an engineer," and he should have a recognized standing in the community as a member of an honourable profession. These two things he gets by belonging to a professional society with a high standard of membership, which also gives him the opportunity to join in contributing to the constructive thought of his time. Such benefits are of special importance to the younger men, who, at the outset of their careers, must take advantage of them if their professional development is to be complete and well balanced.

The promotion of its members' interests in this manner has been an important, if not the main, object of The Engineering Institute of Canada dating from the day in January 1887 when its forerunner, the Canadian Society of Civil Engineers, came into being. The extent to which first the Society and then the Institute have succeeded in the aims so clearly expressed in their organization Charter may be judged by their growth in influence and in number of members, and by the degree of public esteem accorded to membership in them.

In the opinion of many the day is at hand when the engineer will be increasingly concerned in the humanitarian and economic questions of our time. Many of these problems have arisen as a direct result of the engineers' work in developing communication and transportation, providing ample supplies of power, and replacing costly handicraft work by the product of machine tools.

The engineer has thus a responsibility to the public which he can best discharge through the collective action of national engineering societies. Membership in these enables him to make his voice heard on matters of general interest to the community.

During the period covered by The Institute's existence, our country has changed from a mainly agricultural land, of which only a small part had adequate means of communication, to one in which industry and transportation by rail and water have developed to a remarkable degree. A considerable proportion of our population has become urban rather than rural, with all that this involves in the provision of the many amenities made possible by modern technical developments. It has seemed desirable to mark these changes by the publication at this time of a series of monographs, forming a feature of this Semicentennial number of The Engineering Journal, in which the progress of some twenty different branches of engineering and industry in Canada since 1887 has been recorded by some of the men who have themselves been largely responsible for the work accomplished.

This series of papers has been prepared in the hope that the picture they present will give at least a general idea of our progress in Canada during that period, and the contribution of the engineer thereto.

At this fiftieth anniversary of the establishment of The Engineering Institute of Canada, the President desires to express The Institute's most cordial welcome to the delegates, officers and members of sister societies, who are bringing their greetings and are gracing the celebrations with their presence. These visits, and also the many messages of friendship which are being received, are evidence—if any were needed—of the fellow-feeling which ties together engineers of all branches of the profession, wherever they may be carrying on their work.

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# 1887

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# The Story of The Engineering Institute of Canada

## 1887 — 1937

As time passes, events seem to recede gradually in perspective, so that at length it becomes possible to form an estimate of their importance and their effect upon the life of an individual or the development of a society.

In the hurry of modern industrial life few engineers have the inclination and still fewer the leisure to make a survey of past conditions. But the fiftieth milestone in a journey seems a natural point at which to pause and look back, remembering, however, that retrospection in itself is worth little; it is only when the story of the past is used as a guide for the future that its real value is appreciated.

The occurrence of an anniversary such as that which The Institute is now celebrating gives us an opportunity to review the happenings of the past fifty years. It will be timely to place on record some account of the persons and circumstances concerned in The Institute's formation, note the conditions under which they worked, and observe how the methods and organization they adopted have had to be modified to meet the changes which have since occurred.

As far as technical achievements are concerned, the series of papers presented in this number of the Engineering Journal trace the development of some principal branches of Canadian engineering and industry. Such articles, however, necessarily feature the works themselves rather than the engineers who designed, constructed or operated them. The great majority of these men took an active part in the formation of The Canadian Society of Civil Engineers and in the various movements which resulted in its change into the present Engineering Institute of Canada.

Those of us who are now middle aged—to say nothing of those of riper years—have seen remarkable changes in living conditions in Canada. There has been a rapid development in industry, manufactures, and commerce. The telephone, the motor car, the radio, the aeroplane, the growth of existing, and the use of new, methods of communication and transport, are among the influences which have quickened the tempo of life, and so greatly increased its demands on everyone—engineers included.

* * *

Engineering work in Canada dates back to the seventeenth and early eighteenth centuries, when the activities of the French military engineers were naturally directed principally to the construction of the fortifications necessary to defend their infant cities against the incursions of the Indians and the British colonists from the south. Enough of their handiwork remains at such places as Quebec and Louisburg to attest the ability and skill of these pioneers.

In the course of time, the French were succeeded by the British military engineers, who not only erected fortifications, but also built roads and commenced the construction of canals and other public works.

The first road was opened from Quebec to Montreal in 1734, being gradually completed with the growth of the French settlements, and the St. Lawrence canal system was commenced in 1779. A highway from York to Simcoe was constructed in 1794. The canal system was under active development during the beginning of the nineteenth century, the present Lachine canal, (along the line of a smaller channel constructed by the French), having been commenced in 1821, and the Welland canal in 1824, while the Rideau canal was completed in 1832. Many of these works were designed originally for military purposes, but were essential to the development of communications in Upper Canada. With the development of transportation facilities came the civil engineer.

Railway construction commenced in Canada about 1830, the first line, that from Laprairie to St. Johns, Que., having been opened in 1836, but railway development was not at its height until the 'fifties, at which period there was a considerable influx of civil engineers into Canada, many of whom were brought out from Britain, while others came from the United States.

After the Union of Upper and Lower Canada, there arose further demand for efficient and rapid means of communication between the two provinces, and for access to the Atlantic during the winter when navigation is closed on the St. Lawrence. One result of this movement was the construction of the railway from Montreal to Toronto in 1856, so that by 1860, on the completion of the Victoria bridge at Montreal, there were eight hundred miles of direct railway communication from Portland to Sarnia.

In 1867, the Confederation agreement called for the construction of the Intercolonial Railway to connect the Upper and Lower provinces, and this and other projects led again to increased engineering activity.

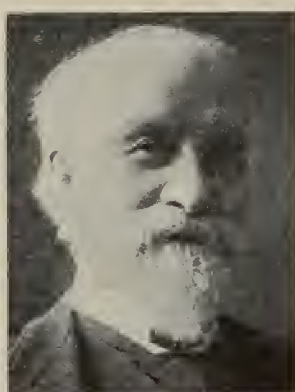
From this time on, small groups of engineers were to be found scattered throughout the Dominion, most of whom, as might be expected, were engaged in work in connection with the construction of the railways, roads, harbours, waterways, and municipal engineering works, the need of which was so pressing at that stage of the country's development. Many of them gained international reputation. Those doing pioneer work often had adventurous careers, and many of their projects had to be carried out with little or no help from experience in older countries where entirely different conditions prevailed. They had to blaze their trails, in some cases literally as well as figuratively.

* * *

What types of men were responsible for this engineering work in Canada during the closing years of the nineteenth, and the opening years of the twentieth century? Space only permits of one or two examples. We may recall, for instance, the romantic career of a young Polish engineer, who after serving in his country's war of independence in 1830 was wounded and made prisoner by the Russians, and who ultimately succeeded in reaching America, landing in New York at the age of twenty-three practically without resources. At first young Gzowski supported himself by teaching music and fencing, but finding engineering employment at length, he came to Canada, where he entered the Government service and was soon put in charge of "roads, harbours, lighthouses and bridges." The location, laying out and supervision of these scattered works, with very limited assistance from men who, though willing, had little engineering knowledge or experience, was no easy task. Communication was difficult, and travel arduous, whether in the saddle, by canoe, or on foot.

In 1850 we find him engaged in harbour work in Montreal, and reporting on the deepening of the St. Lawrence Ship Channel. Turning then to railway work, Gzowski had much to do with the original construction of the Grand Trunk Railway. Years later, he entered the contracting field, and in 1873 his firm built the international bridge across the Niagara River near Buffalo. He proved to be an excellent business man as well as an outstanding engineer, and his wide interests, civil and military, brought him into contact with people in all ranks of life. He was knighted in 1890. From Confederation till his death in 1898 there was no Premier or Governor General who did not avail himself of the advice of Sir Casimir Gzowski.

Sandford Fleming was another pioneer, but of very different type. Educated in a Scottish parish school, he started his career as an apprentice to an engineer and surveyor in Kirkcaldy. On his arrival in Canada, at the age of eighteen, he found employment as a surveyor in Peterborough, then a town of two thousand people.



**Sandford Fleming**

His first construction work was on one of the early railways of Ontario, the Northern Railway, running north from Toronto into then unsettled regions. In 1863 he was chosen by the people of the Red River Settlement, now part of Manitoba, to go to England to urge upon the Imperial authorities the necessity of establishing railway communication between the east and west of Canada. Later, appointed chief engineer of the Intercolonial Railway, he located its route, and displayed some characteristic traits in a strenuous fight with his commissioners for the adoption of iron instead of wood as the material for the railway's bridges. After carrying the matter to the then Prime Minister, Sir John A. Macdonald, he ultimately gained his point.

His greatest engineering undertaking began in 1871, when as engineer-in-chief of the Canadian Pacific Railway he was required to carry out the surveys for the railway across Canada to the Pacific. He determined to undertake the conduct of the expedition himself. His party reached Winnipeg from Lake Superior, travelling by canoe and wagon, via Rainy Lake and Lake of the Woods. Thence to Edmonton the journey was made by pony and Red River cart, and it took two weeks to cover the distance from Edmonton to the Yellowhead Pass. This was the railway route finally advised by Fleming, reaching the Pacific down the North Thompson and the Fraser Rivers, but his recommendations were not accepted. He resigned in 1880 owing to political exigencies; by that time two thousand miles of the Canadian Pacific were under construction.

He was an active advocate for a Pacific cable, and submitted a plan for such a project in 1879, thus beginning an agitation which he led persistently for twenty-three years, until at last his efforts were successful.

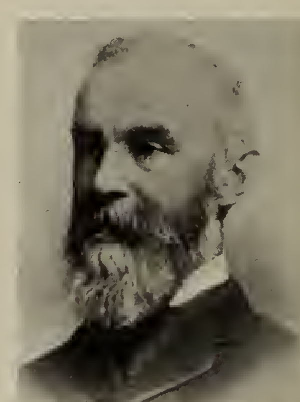
After his appointment as Chancellor of Queen's University in 1880, his continued activity in various public questions, and his writings and speeches in various branches of science and literature, gave him a life of constant usefulness. He received the honour of knighthood in 1897, and closed his long and active life in 1915.

There were of course many other men of high calibre, sketches of whose careers would equally well illustrate the conditions under which engineers performed their work in those days. Not a few of them had records of service to the public and to their country which it would indeed be difficult for their successors to surpass today.

* * *

The first movement towards the organization of an engineering society in Canada appears to have been set on foot before Confederation by Sandford Fleming, who, with some other prominent men, endeavoured to interest members of the profession in the advantages of such an association. Difficulties at that time, however, proved insuperable, and it was not until after the entry of British Columbia into confederation had led to the construction of the Canadian Pacific Railway, and considerable engineering development had taken place in the west, that conditions ripened sufficiently to enable a society to be organized with success.

In May 1880, Mr. E. W. Plunkett, a well known engineer of Irish extraction, circularized his fellow engineers in Canada, setting forth the necessity and advantages of organization. Possibly as a result of the circular, an attempt at the legal regulation of civil engineers in Ontario was made in February 1881, when "an act respecting civil engineers" was introduced in the Legislative Assembly of that province. However, the bill did not commend itself to the Legislature, or, indeed, to all of the engineers named in it, and it never became law.



**Alan MacDougall**

About this time, the authorities of Toronto and McGill Universities realized the importance of having educational facilities for training engineers, and the advantages of having an association with which to co-operate, if such could be formed. Further, Montreal, Toronto and Ottawa were the cities most frequented by the profession, and conditions suitable for the formation of a society were gradually developing at these places.

The idea of a Canadian engineering society was apparently present during this period in the minds of many members of the profession, and during the construction period of the Canadian Pacific Railway the scheme was very thoroughly canvassed by a number of men both in Ontario and Quebec who later became officers or prominent members of the Society they were proposing to form. Their number included Alan MacDougall, C. E. W. Dodwell, T. C. Keefer, Sandford Fleming, J. L. P. O'Hanly, S. Keefer, Frank Shanly, Kivas Tully and others. At length, in February 1886, Alan MacDougall of Toronto issued a circular over his own signature advocating the formation of an association, and as a result a number of meetings were held in Toronto, Ottawa and Montreal. Of these meetings perhaps the most important was that of the fourth of March, held in Montreal at the Harbour Commissioners' office, of which the manuscript minutes have been preserved. Alan MacDougall was in the chair, and P. W. St. George acted as secretary. At this meeting it was moved by H. D. Lumsden, seconded by P. A. Peterson, and resolved

> "That a society of engineers in Canada be formed comprising all branches of engineers, and that a committee be appointed to meet the other committees of engineers from other cities, and then to arrange and form a preliminary constitution, which form of constitution shall be sent around to those gentlemen who send in their names as being willing to form such a society; and that each gentleman present be requested to forward the names of engineers and their addresses to the local secretary."

A Montreal local committee was then appointed, and its meeting resulted in a draft constitution for the proposed society.

On the 30th of March, 1886, as the result of conversations between Mr. R. A. Davy and Lieut.-Colonel W. P. Anderson, a meeting took place in the City Hall, Ottawa, and was addressed by Alan MacDougall. The Montreal draft constitution was considered and afterwards amended by the Ottawa local committee.

Meanwhile a similar local committee had been acting in Toronto, and had appointed delegates to confer with those from Ottawa and Montreal.

The Montreal committee held another meeting on November 11th, 1886, and considered a printed constitution which in the interval had been prepared and amended by correspondence between the local committees at Montreal, Toronto and Ottawa. A provisional committee was then formed, first to revise and complete the constitution and second to establish the association. This provisional committee consisted of:—Colonel C. S. Gzowski, Kivas Tully, W. T. Jennings, A. MacDougall, T. C. Keefer, H. F. Perley, W. P. Anderson, R. Surtees, H. T. Bovey, J. Kennedy, P. A. Peterson and P. W. St. George. Mr. MacDougall was appointed provisional secretary.

On December 9th, 1886, the provisional committee held a meeting at the St. Lawrence Hall, at which it was decided to call the proposed society the "Canadian Society of Civil Engineers." At this meeting it was further resolved that the provisional committee should hold a meeting on the second Tuesday in January for the election of members and to decide on a date for a general meeting of the Society.

Accordingly, on January 19th, 1887, the provisional committee met again in Montreal, to consider the list of applicants for membership, and continued their session on the following day. One hundred and sixty-two elections to membership were effected.

Again, on the 21st of January and the 3rd of February, 1887, further meetings of the provisional committee were held, and, on the latter date, the membership was further augmented. Elections were made in this way up to February 24th, on which date 288 members of all classes had been elected.

The first officers were elected by letter ballot, which was sent to members who joined previous to February 24th, and was canvassed at the first general meeting. This was held on Thursday, February 24th, 1887, in the board room of the Harbour Commissioners' building, Montreal. The result of the ballot was announced and the reports and actions of the provisional committee were adopted and approved.

The minutes of this gathering can be found in the first annual report of the transactions of the Canadian Society of Civil Engineers, together with a list of those present. Representatives had come from Toronto, Ottawa and other places, and it was decided to apply to the Dominion Government for a charter.

* * *

The charter was carried through Parliament by one of the vice-presidents, Walter Shanly, M.P., and received Royal sanction on June 23rd, 1887. It incorporated the

**Walter Shanly**

Society, defined its objects and powers, and enabled it to pass regulations and by-laws for the direction and management of its affairs.

The following were named as its first members:—Thomas C. Keefer, Ottawa; Casimir S. Gzowski, Toronto; John Kennedy, Montreal; Henry T. Bovey, Montreal; Frederick N. Gisborne, Ottawa; Edmund P. Hannaford, Montreal; William T. Jennings, London; Samuel Keefer, Brockville; Louis Lesage, Montreal; Hugh D. Lumsden, Toronto; Alan Macdougall, Toronto; Henry F. Perley, Ottawa; Hurd Peters, Saint John, New Brunswick; Peter A. Peterson, Montreal; Henry S. Poole, Stellarton, Nova Scotia; Henry N. Ruttan, Winnipeg; Collingwood Schreiber, Ottawa; Percival W. St. George, Montreal; and Herbert Wallis, Montreal, "and all other persons who may hereafter be associated with them."

Twelve of these men afterwards served as Presidents of the Society.

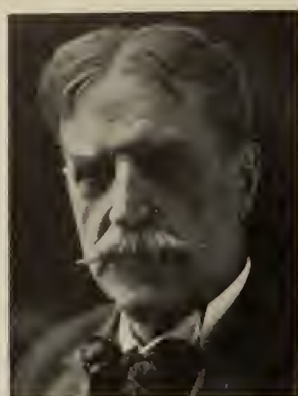
The objects of the Society, as set forth in its Act of Incorporation were "to facilitate the acquirement and interchange of professional knowledge among its members, and more particularly to promote the acquisition of that species of knowledge which has special reference to the profession of civil engineering, and further, to encourage investigation in connection with all branches and departments of knowledge connected with the profession." The Society was also given power to make regulations and by-laws "including all rules that may be deemed necessary for the maintenance of the honour and dignity of the profession." These aims, as more particularly defined and expanded in the by-laws, have remained unchanged to the present day.

The By-laws of the Society made it clear that the term 'civil' engineering, used in the Act, had reference to all types of engineering activity other than military.

It should be remembered that in 1887 mechanical, chemical, mining, electrical and other specialized branches of engineering as we now know them, were only in process of development in Canada. It was therefore inevitable that most of the early members of the new organization should be men engaged in railway surveys or construction, in contracting for public works, or in municipal or government service. The founders of the new body could not possibly foresee the extent of future development of all branches of engineering work in Canada, but they realized the trend, and accordingly the by-laws of the Society provided that its membership should include every branch of the profession.

* * *

Space will not permit more than a brief mention here of the men who were actively engaged in the formation of the Canadian Society of Civil Engineers. Sketches



C. E. W. Dodwell

of the careers of those among them who afterwards served as presidents will be found in the pages following this article. Some notes regarding a few of the other founders may, however, be added at this point as further picturing the kind of men who worked so effectively for the establishment of the new body.

One of the most active among them was Alan MacDougall, a Scotsman who had received his engineering training with the North British Railway, and on coming to Canada entered the service of the Canadian Pacific Railway, then in its early stages. Later he became a consulting engineer in Toronto. He was greatly interested in the status of the engineer and in the training of young engineers. During the 90's it became evident that the English pupilage system for the training of engineers was not altogether suitable for Canadian conditions. The engineering schools at the Canadian universities were just then beginning their development, and MacDougall took the matter up, commenting on the apathy of his professional brethren as regards questions of engineering education. He retained his interest in the Society and its work until his death in 1897.

One of MacDougall's colleagues in the Canadian Pacific service in Toronto was a fellow member of the Institution of Civil Engineers, C. E. W. Dodwell, with whom he used to discuss the various organization problems of the profession. Mr. Dodwell, on his transfer to Montreal in 1885, continued the discussions there, and found that his ideas as to the formation of an engineering society were favourably received. After leaving the Canadian Pacific in 1891, he entered the Government service, ultimately becoming superintendent district engineer for the Public Works Department in Halifax. He was a man of broad views, liberal education, and great intellectual activity, and had the question of professional status very greatly at heart. It was under his chairmanship that a committee of the newly transformed Engineering Institute of Canada drew up the draft by-law in 1919 which formed the basis of the present provincial legislation establishing the various provincial Associations of Professional Engineers. Dodwell may, in fact, be regarded as the father of engineering legislation in Canada. He became the first president of the Association of Professional Engineers of Nova Scotia, and his services to the profession were fitly recognized in 1922 by his election as an Honorary Member of The Institute.

In Ottawa, discussions appear to have been initiated by R. A. Davy, an older engineer of wide experience in railway location and construction. Davy was able to interest Lieut.-Colonel W. P. Anderson, chief engineer of the then Department of Marine and Fisheries, and their combined energy launched the scheme there. We are indebted to Mr. Davy for a collection of reminiscences which gives the most complete historical record of the formation days which is now available.

Though he never became president, Collingwood Schreiber, then chief engineer of the western end of the Canadian Pacific Railway, served several terms on the Society's Council, and aided in much of the early development work. This distinguished engineer later became chief engineer and deputy minister of the Department of Railways and Canals, and in 1905 was appointed general consulting engineer to the Dominion Government. After leaving the Canadian Pacific Railway service he was largely concerned with the developments which led to the building of the transcontinental railways which were afterwards taken over by the Dominion Government.

Among the founders of the Society who did not become President there may also be named Hurd Peters, city engineer of Saint John; H. F. Perley, chief engineer of the Department of Public Works, Ottawa; Louis Lesage, the man who developed the waterworks system of Montreal, and F. N. Gisborne, general superintendent of Government telegraphs, Ottawa, one of the prime movers in trans-Atlantic telegraphy.

It was decided to locate the Society's headquarters in Montreal, where accommodation for its meetings was at first provided by the kindness of McGill University. As the Society developed and funds became available, it was found possible to lease suitable rooms, so that in 1890 the Secretary's office and the library were moved to the upper floor of the Bank of Montreal building at the corner of Mansfield and St. Catherine streets. The need for extension was soon felt, and was met in 1899, when a house at 877 Dorchester street was bought and adapted for the Headquarters of the Society. There Headquarters remained until 1913, when a building at 2050 Mansfield street was purchased and enlarged so that better facilities for the office staff, library and meeting rooms could be provided.

From the outset the young Society showed healthy growth, indicated by the fact that its original membership of about three hundred doubled itself in the first ten years of its existence; in thirty years the membership had reached the three thousand mark.

Its real beginning, however, was at the meetings in January and February 1887, at which its earliest members joined and planned its structure and organization. Twenty-four of these pioneers are still with us,* although their ranks are gradually thinning out.

It must be with a feeling of real satisfaction that these senior members witness the fiftieth anniversary of the establishment of the Society whose success is so largely due to their loyal support during its early years.

In drawing up the original by-laws of the Society it was realized that the membership of such a Dominion-wide body would necessarily be scattered geographically, and that as far as possible a decentralized type of organization should be adopted. For this purpose the formation of local branches was authorized; later, geographical districts and provincial zones were provided for. The first branch was formed in Toronto in 1890; the second in Cape

*The list is headed by T. H. White, of Vancouver, now eighty-nine years of age, who joined as a Member at the meeting of January 20th, 1887.

Breton in 1905.* By 1912 branches had been formed in Quebec, Winnipeg, Ottawa, Vancouver, Kingston, and Victoria, and others followed as opportunity occurred, until to-day there are twenty-five, located in the principal cities of the Dominion from Sydney, Cape Breton, to Victoria, Vancouver Island. These branch organizations perform an indispensable function, giving The Institute a local habitation in every important centre, and stimulating there an appreciation of the engineer and his work, both in a personal and a professional sense.

The growth of the membership in numbers was accompanied by a corresponding increase in the diversity of the branches of engineering followed by the members. This soon resulted in the formation of four sections, general, electrical, mechanical and mining. After about ten years of the Society's existence it was felt by some members that the term 'civil' engineering had come to be generally used in a much more restricted sense than that in which it had been employed at the time of the Society's foundation; this feeling was later to be one of the motives leading to the change in the Society's name and the wider extension of its activities.

* * *

Following the outbreak of the War in August 1914, many of the Society's members joined the Canadian forces and proceeded overseas. Under war conditions the maintenance of the Society's activities became a difficult task. Finance was a problem which had to be solved by determined retrenchment. The Council nevertheless remitted the annual fees of members serving overseas and established a modest fund for their families. Representations were made to the Dominion Government respecting the training of engineer officers, in view of the fact that many engineers were serving in units where their professional knowledge could not be utilized; the Council further expressed the Society's desire to co-operate with the Government in this matter.

*This branch appears to have been discontinued later, and reformed in 1921.

A bronze Memorial Tablet in the Headquarters building in Montreal records the names, ranks and honours of 119 members of the Society who were killed in action or died of injuries received while on active service, from 1914 to 1919.

The total number of members who served overseas was 949; their names and honours will be found on a bronze Record Tablet now erected near the Memorial. Of the total membership at the outbreak of the War over thirty-two per cent served in the Allied Forces.

* * *

Among the members of the Society there were always many who felt that in addition to promoting the dissemination of professional knowledge the new body should take steps to enable the public to distinguish between qualified and unqualified engineers. At the Annual Meeting of 1896 a committee was appointed to consider the question of professional status, the chairman being Mr. Alan MacDougall. In consultation with provincial subcommittees a draft act of provincial incorporation was prepared, which, with some modifications, became law in Manitoba in 1896, and in Quebec in 1898, limiting the practice of 'civil' engineering to members of the Society. These enactments, however, did not prove satisfactory in operation, and further provincial legislation was not attempted at that time.

It was not until 1917 that renewed interest was awakened in the subject, in connection with the report of a Committee on Society Affairs, whose chairman was Professor H. E. T. Haultain. That committee was appointed "for the purpose of studying and reporting upon the policy

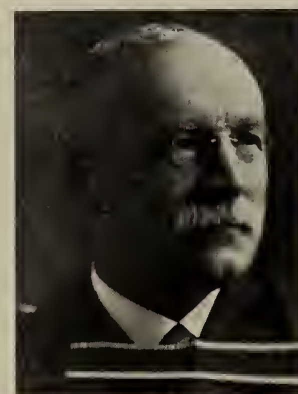
**Group taken at the Annual Meeting of the Canadian Society of Civil Engineers at the Montreal Headquarters—1897.**

for increasing the prestige and influence of the Society" including a consideration of the organization and by-laws. Its report suggested a number of important changes, including the appointment of a whole time secretary, the establishment of a monthly journal, and a change in the Society's name. Meetings in Alberta and in Ottawa during 1917 had also urged the desirability of action regarding professional status, and this question received a further impetus in 1918 after the name of the Society had been changed and its organization extended. The action which followed at that time will be briefly reviewed later.

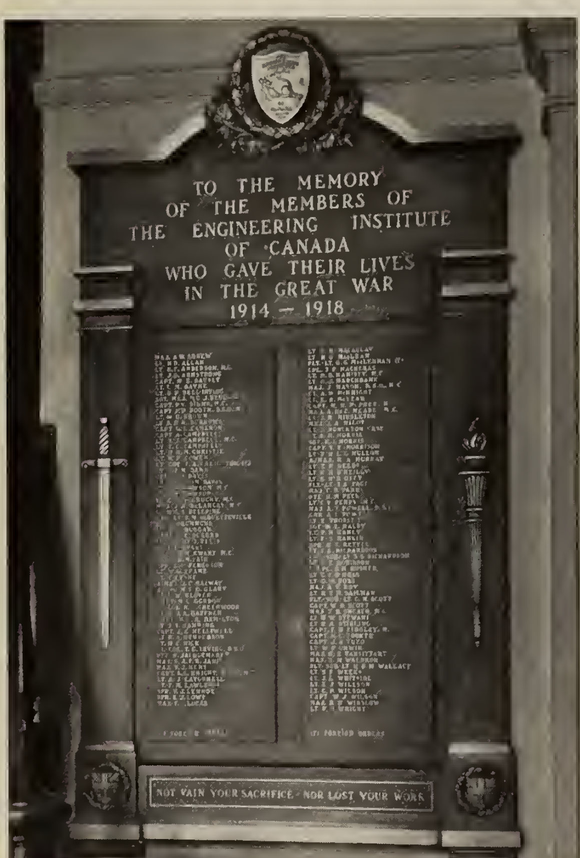
As a result of the work of the Committee on Society Affairs appropriate steps were taken, and an Act of the Dominion Parliament was obtained, which became effective on April 15th, 1918, changing the Society's name to The Engineering Institute of Canada, a title which was thought more expressive of its aims and functions. New by-laws were prepared, providing for more comp'ete branch organization and representation, the formation of provincial divisions, and other desirable changes; the Engineering Journal was established as the organ of The Institute; a whole time secretary was appointed, and as a result growth in membership was resumed and the activities of the Institute and its branches showed renewed enthusiasm. At the first General Professional Meeting of the Engineering Institute of Canada, held in Toronto in March 1918, President H. H. Vaughan pointed out that one of the motives underlying the change in name and organization was the desire "to unite all engineers in Canada, to whatever branch of the profession they may belong, in one society."

During the next three years eleven more branches were formed, and the membership increased from over three thousand to nearly five thousand.

The secretary during the first five years of the Society's existence was Professor H. T. Bovey of McGill University. He was followed in 1891 by Professor C. H. McLeod, who watched over the growth of the organization during the succeeding twenty-five years, and saw it reach maturity. When he died in 1917 the duties had become so onerous that at the beginning of the new regime a full time secretary was found necessary; Mr. Fraser S. Keith was then appointed as General Secretary and as the first editor of the Engineering Journal. On his resignation in 1925 he was succeeded by Mr. R. J. Durley.



**Professor C. H. McLeod**
Secretary, 1891-1916




**Memorial Tablet**

The reorganization was barely completed when the question of legislation regarding professional status was again brought up, this time in August 1918, at the Second Professional Meeting of The Institute at Saskatoon, when the subject was ably discussed in a paper by Mr. F. H. Peters, then of Calgary. At that time provincial legislation was being suggested in Manitoba, Saskatchewan and Alberta. The expressions of opinion at that meeting were in favour of action by The Institute in order to promote uniform legislation in all the provinces.

At the following Annual General Meeting in Ottawa in February 1919 a committee was appointed, under the chairmanship of Mr. C. E. W. Dodwell, to draw up a model act for consideration in the proposal of provincial enactments. This was done, and when submitted to the corporate membership for ballot in July 1919 met with general approval. The Institute Council accordingly endorsed the model act, and passed it to the branches and provincial divisions for suitable action in their respective provinces. During 1920 provincial acts based on this model were obtained in British Columbia, Quebec, Manitoba, Alberta, New Brunswick and Nova Scotia. By 1923 similar legislation had been obtained in all the provinces except Prince Edward Island and Saskatchewan. An act was obtained in the latter province in 1930.

It is perhaps unfortunate that the relations of The Institute (a voluntary body) with the new Associations (provincially constituted bodies having compulsory membership), could not be clearly defined from the outset, for it soon became evident that such questions as the duplication of fees and the diversity of standards for admission as between the associations and The Institute, and also between the associations themselves, would have to receive consideration. On the invitation of The Institute Council in December 1925, a conference of delegates of the provincial Professional Associations was held in Montreal in February 1926. The principal item on the agenda of this meeting was co-operation with The Engineering Institute of Canada. The seven associations then existing were represented, and the delegates left with a resolution recording the sense of close association developed by the conference and their appreciation of the courtesy extended to them by The Institute.


**The Members of The Institute who Served Overseas 1914-1918**
(Record on Bronze Tablet 12 ft. 8 in. by 5 ft. 9 in.)

In the following year an endeavour was made by the Council of The Institute to interest the governing bodies of the various provincial associations in a movement to bring about substantial uniformity in the requirements for admission by examination to the several professional associations and to the Institute. The desirability of such joint action was one of the topics considered at the first Plenary Meeting of the Council of The Institute held in October 1927, at which a standing committee was set up to study this and other problems involved in co-ordinating the activities of The Institute and the several associations of Professional Engineers. This committee continued to function until 1931 in an effort to obtain joint action with the associations. It was then found desirable for The Institute representatives to stand aside, following representations that the associations should first come to an agreement among themselves. At this stage the matter rested for a time, awaiting further action by the associations. Meanwhile the Council of The Institute again expressed its desire to co-operate with the associations in furthering the best interests of the profession throughout Canada.

During 1934 the Council received communications from the Winnipeg, Halifax and other branches, making suggestions for co-operation with their local provincial associations. Before definite action could be taken, however, the subject became the chief matter of debate at the Annual General Meeting of The Institute in February 1935, with the result that a Committee on Consolidation was formed under the chairmanship of Mr. Gordon McL. Pitts. That committee, after two years of strenuous work, prepared a series of proposals for the amendment of The Institute by-laws, defining the lines along which, in the committee's opinion, The Institute could best co-operate with the associations. These amendments, however, did not carry when submitted to ballot, and it would seem that a solution acceptable to The Institute membership as a whole has yet to be found.

* * *

With its twenty-five branches, scattered over seventy degrees of longitude, the problem of effective representation of the branches on The Institute's Council is not an easy one. Much can be done to keep the branches informed of Institute problems and conditions by the personal visitations, which many of the presidents and vice-presidents are able to make from time to time. The Journal is an effective means of communication and reaches the membership individually. An important step towards effective branch representation on matters of Institute policy was taken in 1927, when the First Plenary Meeting of Council was held, attended by twenty-nine out of its forty-two members, for the purpose of discussing Institute affairs. Since then, similar meetings have been held each year except 1932, 1934 and 1935, their number having been limited by considerations of expense. It is generally agreed that these Plenary Meetings have proved of inestimable value, enabling councillors from all parts of the Dominion to know each other, exchanging ideas and reconciling divergent viewpoints.

**Fraser S. Keith**
General Secretary, 1917-1925

Reference should be made to the work accomplished by many of The Institute committees, particularly those dealing with problems of organization. Following the Committee on Society Affairs in 1916, and the committee which drew up the model act in 1919, a committee on Policy was appointed in 1920 under the chairmanship of Mr. J. B. Challies. Its report, presented in 1923, resulted in a new expression of many lines of policy, later embodied in important changes in the by-laws. The work of the Committee on Relations with Professional Associations, 1927-1931, has already been mentioned. A new Committee on Policy, whose chairman was Dr. O. O. Lefebvre, was appointed in 1929, and presented its report in the following year. In 1931 a Committee on Development, under the chairmanship of Mr. J. L. Busfield, commenced a comprehensive review of the constitution and aims of The Institute. It reported in 1933; its proposals for further changes in the by-laws, however, failed to carry on ballot.

In addition to these and other committees dealing with purely Institute affairs, committee work has been done on many subjects of public, professional or technical interest. Among them may be mentioned Fuel, the Deterioration of Concrete in Alkali Soil, the Western Water Problem, Standard Construction Contract Forms, Members Unemployment and Low Cost Housing. The Institute has co-operated actively with the National Construction Council and the Canadian Chamber of Commerce in regard to questions studied by them which affect engineering work. These notes indicate some of the activities directed by Council, which have as their object the well-being of the membership of The Institute and the progress of the engineering profession in Canada.

Among the many prizes and medals awarded annually by Council, some are marks of professional distinction, like the Sir John Kennedy Medal, and others, like the Duggan Prize and the Past-Presidents' Prize, are given to encourage the preparation of professional papers of a high order of merit, or as a recognition of good work by Students or Juniors of The Institute.

Mention may also be made of various services for members. There are, for instance, facilities at Headquarters for furnishing, on request, bibliographies or lists of references to current technical publications for the benefit of members of The Institute, and to supply photostat copies of these.

The Institute's Employment Service Bureau maintains a file of the qualifications and engineering experience of the members registered, and is thus enabled to render a valuable service, without charge, both to members seeking employment and to firms employing engineers.

Like many other public organizations, The Engineering Institute of Canada was seriously affected by the depression years; there was a drop both in membership and revenue. A substantial proportion of the members were indeed without employment, a condition which the Council recognized by the establishment of a Non-Active List containing, at one time, nearly seven hundred names. During these difficult times a number of the branches took steps to assist those of their members who were in financial stress by collecting and distributing local funds. This course did much to help many deserving members, and restore their normal outlook on life. Recent figures show marked improvement and indicate that The Institute membership is again resuming its normal rate of growth.

* * *

What of the future? This brief story of the origin and progress of The Engineering Institute of Canada pictures an organization aiming to advance the scientific and engineering knowledge of its members; to set for them a high standard of professional competence and ethics; to advance their professional, social and economic welfare, and to aid them in fulfilling the engineer's obligation to the public. As in the case of all human institutions, actual performance has fallen short of the ideal; there have been many lines along which advance has been desirable but has not been found possible. Nevertheless, the story shows that worth while results have been obtained, and that the benefits derived from membership have been due entirely to the active and unselfish labour of individual members of the organization.

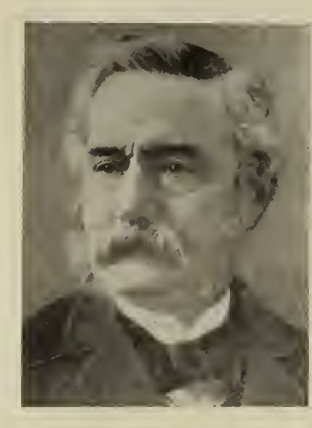
The Institute's influence has made for unity and solidarity among engineers of all branches of the profession in Canada, and has done much to give them a Dominion-wide viewpoint, in contrast to that sectional outlook which, if carried too far, blocks progress instead of promoting it.

May we not expect that in the future this influence will grow, and that the members of the engineering profession in Canada, whether practising independently or working in the service of a government or industrial corporation, will realize to an increasing extent the fact that advance can only result from united effort?

# Notable Figures in The Institute's Past

## Past-Presidents

THOMAS COLTRIN KEEFER (1821-1915), author and eminent engineer, was born at Thorold, Ont. and educated at Upper Canada College. His first engineering work was on the Erie canal, and later the Welland canal. In 1849 one of his most important publications "The Philosophy of Railways" appeared and in the same year he won Lord Elgin's prize for his book "The Influence of the Canals of Canada on Her Agriculture." Mr. Keefer was appointed Commissioner for Canada to the First International Exposition in London in 1851, in 1878 he was Executive Commissioner at the Paris Exposition, was made a C.M.G. by Her Majesty, and elected an Officer of the Legion of Honour (France.) After making an investigation of the St. Lawrence channel, he engaged in preliminary surveys for the Grand Trunk Railway for the line between Montreal and Toronto and prepared plans for bridging the St. Lawrence at Point St. Charles, resulting in the building of the Victoria bridge. He designed and built Montreal's first aqueduct, in 1874-75 was chief engineer of the Ottawa Waterworks Commission and was afterwards engineer to the Montreal Harbour Commission. A Fellow of the Royal Society of Canada, he was President of the American Society of Civil Engineers in 1888. Mr. Keefer was one of the founders of the Canadian Society of Civil Engineers, and became an Honorary Member in 1903.



THOMAS COLTRIN KEEFER, C.M.G., LL.D.
President, 1887 and 1897

SAMUEL KEEFER (1811-1890), railway and canal engineer, was a descendent of United Empire Loyalists who came to Ontario from New Jersey. His early education was at the country schools, and his first insight into engineering work was upon the Welland canal, operated by a company of which his father was the president. After two years at Upper Canada College, Samuel Keefer in 1833 was appointed secretary to the Board of Commissioners for the Improvement of the River St. Lawrence. On the establishment of a Board of Works for the United Provinces, (resulting from the union of Upper and Lower Canada) he became engineer to that Board in 1841. For a man of thirty, the responsibilities of this position were not light. Besides the reconstruction and enlargement of the Welland canal, he had to deal with the canals upon the St. Lawrence and Richelieu rivers, and with the demands for highway communication over a territory extending from Gaspé to Lake Huron. He constructed many bridges, including the first suspension bridge in Canada at the Chaudiere Falls, Ottawa. When the railway era began, like many other engineers, he turned his attention to railway work, becoming inspector of railways in 1857. Retiring from the public service in 1864, he continued the practice of his profession until his death.

SAMUEL KEEFER
President, 1888

CASIMIR STANISLAUS GZOWSKI (1813-1898), railway consulting engineer and contractor, was born at St. Petersburg, Russia, attended the Military College at Kremenetz, and in 1830 obtained a commission in the Imperial Russian Engineers. However, owing to the part which he took in the Polish insurrection of 1830-1831, he was, after being confined in a military prison, shipped to the United States, landing in New York in 1833. In order to perfect himself in the English language, he articled himself as a student in law in Pittsfield, Mass., and in 1837, was admitted to the bar, and practised in Pennsylvania until 1841. In that year he moved to Toronto, obtained a position in the Department of Public Works, and became superintending engineer of roads and harbours in western Ontario. In 1846 he became a naturalized British subject, and from 1850 to 1853 was engineer of the harbour works at Montreal, and consulting engineer on channel improvements between Montreal and Quebec. Casimir Gzowski next became chief engineer of the main line of the Grand Trunk Railway between Montreal and Island Pond, and later, resigning, entered into partnership with Sir Alexander Galt, the Hon. H. Holton and Sir David Macpherson for the construction of the Grand Trunk main line from Toronto to Sarnia. He was also interested in military matters, acted as President of the Dominion Rifle Association and in 1879 was gazetted a Colonel and an honorary A.D.C. to the Queen. He was created K.C.M.G. in 1890. Sir Casimir was one of the founders of the Canadian Society of Civil Engineers.

SIR CASIMIR GZOWSKI, K.C.M.G., A.D.C.
President, 1889, 1890, 1891

Sir John Kennedy, LL.D., D.C.L., Hon.M.E.I.C.
President, 1892

P. Alex. Peterson
President, 1894

John Kennedy (1838-1921), railway and harbour engineer, was born at Spencerville, Ont., and educated at McGill University. While still a young man he had risen to the position of chief engineer of the Great Western Railway System and in 1875 when the deepening of the St. Lawrence River ship channel was determined upon, the management of the work as well as harbour enlargement was put into his hands as chief engineer. On the revival of trade in 1888 the Commissioners instructed Mr. Kennedy to prepare a scheme for the enlargement of the Port of Montreal; this work was commenced in 1890, under his supervision. In 1899 Mr. Kennedy's eyes became affected by an incurable ailment, so that by 1907 his sight was so far gone that he resigned his position as chief engineer, the Commissioners appointing him their consulting engineer. He served on many Royal Commissions; in 1916 his services were recognized by a knighthood; in 1917 the degree of LL.D. was conferred on him by McGill University and in 1921 that of D.C.L. by McMaster University.

Edmund Phillips Hannaford (1834-1902), railway engineer, was born at Stoke Gabriel, Devon, England, coming to Canada in 1856, and joining the staff of the Grand Trunk Railway Company. For nine years he acted as assistant engineer and then engineer of the western division, and in addition was chief engineer on the construction of a bridge over the Niagara river, which was completed during 1873. Mr. Hannaford was at this time made chief engineer of the Grand Trunk System, and among the many works undertaken during his tenure of office were the construction of the Montreal and Champlain Junction Railway, the United States and Canada Railway, the erection of general offices at Point St. Charles, the original Union Station at Toronto and the passenger station at Montreal. He was a charter member of the Canadian Society of Civil Engineers.

P. Alex. Peterson (1839-1913), railway engineer, was born at Niagara Falls, Ont. and in 1859 was articled to Thomas C. Keefer. From 1863 to 1867 he was engaged on various engineering works, and in 1867 was appointed resident engineer of the Northern Division of the New York and Oswego Midland Railway. In 1872 he was made chief engineer of the Toronto Water Works, then about to be constructed. Commencing in 1875 he became in turn chief engineer of a section of the Quebec, Montreal, Ottawa and Occidental Railway, the Atlantic and North West Railway and in 1890 the Canadian Pacific Railway, holding this position until 1902, when, owing to ill health, he was appointed consulting engineer, retiring in 1908. Mr. Peterson was a charter member of the Society and was a vice-president in 1889, 1892 and 1893.

Thomas Monro (1831-1903), railway and waterways engineer, was born at Londonderry, Ireland, and coming to Canada in 1850 was employed under T. C. Keefer. From 1854 he was on the construction of the Grand Trunk Railway near Prescott, the Hamilton and Port Dover Railway and the Hamilton waterworks. From 1860 until his death Mr. Monro was in the service of the Canadian Government filling many responsible positions, including an appointment as inspector of railways. In 1871 he located the new Welland canal and in 1889 a 14-foot canal between Lakes St. Louis and St. Francis. This work, including all structures, was designed by Mr. Monro, and carried out under his supervision. He designed the waterworks for the city of St. Catharines, and in 1895 was chairman of a board reporting on the harbour of Montreal. A charter member of the Society, he served on Council and as a vice-president.

Herbert L. Wallis (1844-1922), mechanical engineer and designer, one of the outstanding figures in the early history of the engineering development of Canadian railways, was born at Derby, England, and educated at Ockbrook, serving his apprenticeship with Matthew Kirtley, locomotive superintendent of the Midland Railway. In 1871 he came to Canada as assistant mechanical superintendent of the Grand Trunk Railway at Montreal, and two years after became chief mechanical superintendent. He retired in 1896. The first compound locomotive upon the Grand Trunk Railway was built by Mr. Wallis, who was instrumental in improving the shops of the company so as to construct practically all the new locomotives for its service. He joined the Society on January 20th, 1887, served on the Council from 1887 to 1893, was Treasurer, and in 1894 became a vice-president.

Edmund Phillips Hannaford
President, 1893

Thomas Monro
President, 1895

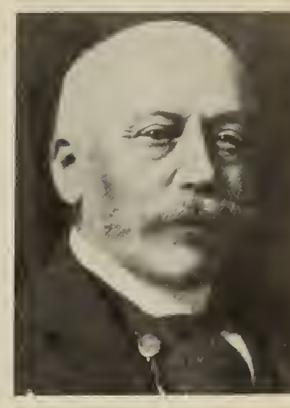
Herbert L. Wallis
President, 1896

William George MacNeill Thompson (1832-1903), railway and canal engineer, was born at Saltford, Lancashire, England, and from 1852 to 1856 was engaged on the construction of the Grand Trunk Railway from Toronto westward. He was subsequently, until 1859, resident engineer on the Welland Railway, then contractors' engineer on the Rivière du Loup section of the Grand Trunk Railway, and the reconstruction of the Northern Railway. In 1863 Mr. Thompson was engineer and manager for Dyphwys Cassen Mining Company in North Wales, and in 1864 went to Ceylon. Returning to Canada in 1868 he was resident engineer on the construction of the Intercolonial Railway, from 1872 to 1889 on the southern division of the Welland canal enlargement, and later the Sault Ste. Marie canal. He was a member of Council of the Canadian Society of Civil Engineers in 1895, and a vice-president in 1896 and 1897.

William Tyndale Jennings (1846-1906), railway, municipal and consulting engineer, was born in Toronto and receiving his education at Upper Canada College, began his professional career in 1869 under T. N. Molesworth. In 1870 he entered the service of the Great Western Railway and on its completion in 1875 was appointed locating engineer on the British Columbia section of the Canadian Pacific Railway. In 1890 he became city engineer of Toronto, resigning in 1891 to enter private practice as a consulting engineer. From 1892 to 1895 he was chief engineer of the British Columbia Southern Railway. He reported in 1897 on a route from Fort Wrangel on the Pacific coast to Teslin Lake, also among others on the country between Lake Nipissing and James Bay, and on the dry docks at Halifax and Esquimalt. He was a charter member of the Canadian Society of Civil Engineers, a councillor and a vice-president.

William Tyndale Jennings
President, 1899

Henry T. Bovey (1852-1912), first dean of the Faculty of Applied Science of McGill University, was born in Devonshire, England, and educated at Queen's College, Cambridge, coming to Canada in 1878 as professor of civil engineering and applied mechanics at McGill University. He was one of the founders of the Canadian Society of Civil Engineers, held office as secretary-treasurer or member of Council for many years, and was vice-president of the Society in 1896-97. Following his resignation from McGill University in 1908, he was appointed rector of the Imperial College of Science and Technology, London. Dr. Bovey received many distinctions in the academic world, including the Fellowship of the Royal Society of London, an honorary LL.D. from McGill and Queen's Universities, the degree of D.C.L. from Bishop's College, and an Honorary Fellowship of his old College at Cambridge.

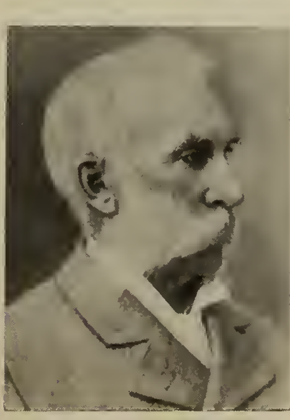


Edward Henry Keating
President, 1901

Edward Henry Keating (1844-1912), railway, municipal and consulting engineer was born at Halifax, N.S. and educated at Dalhousie College. He studied engineering under George Whiteman, in Nova Scotia, and was with the Truro and Pictou, the Windsor and Annapolis, and the Intercolonial Railways. From 1873-1890 he was city engineer of Halifax, and also designed waterworks for Truro, Windsor, Dartmouth and Moncton. He was later city engineer of Duluth, Minn. and then chief engineer of Toronto, Ont. In 1898 Mr. Keating became general manager of the Toronto Street Railway, and in 1904 went to Mexico as engineer and manager of construction with the Monterey Railway Light and Power Company. Latterly he acted as consulting engineer and arbitrator in valuation disputes. He served as a member of Council for three years, and as a vice-president for two years.

Martin Murphy (1832–1926), railway, highway and bridge engineer, was born at Cooleycarny, Wexford, Ireland, and educated at Ballindagin National School. He occupied several positions before coming to Canada to become city engineer of Halifax in 1868. After two years he became engaged in railway survey work in Nova Scotia, and then as a contractor on the construction of bridges on the Intercolonial Railway. In 1875 he was appointed provincial chief engineer for the government of Nova Scotia, which position he occupied for many years. Subsequent to his retirement he acted as inspection engineer on the construction of the western division of the Transcontinental Railway. Dr. Murphy was noted for his work on railway bridges and received the degree of D.Sc. from King's College, Windsor, N.S. He was a member of Council of the Society in 1888, 1889 and 1897, and a vice-president in 1895.

William George MacNeill Thompson
President, 1898



Henry T. Bovey, D.C.L., LL.D., F.R.S.
President, 1900

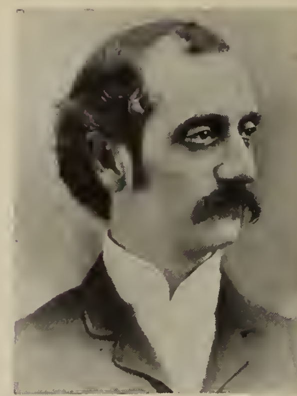
Martin Murphy, D.Sc.
President, 1902

Kennet William Blackwell
President, 1903

Kennet William Blackwell (1850-1920), mechanical engineer and manufacturer, was born in Wiltshire, England, and came to Canada as a youth. He was educated at Bishop's College, Lennoxville, and apprenticed as a mechanical engineer in the shops of the Grand Trunk Railway, later becoming mechanical superintendent for that railway and subsequently joining the Canadian Pacific Railway in the same capacity. In 1882 he went into the manufacturing business, the firm eventually becoming Montreal Steel Works Limited, of which he was president and managing director. This company was later absorbed by the Canadian Car and Foundry Company under the name of Canadian Steel Foundries Limited, with Mr. Blackwell as vice-president. He was a vice-president of the Merchants Bank of Canada and a director of other prominent business concerns. He served on the Council of the Society for five years, and was a vice-president in 1898 and 1899.

William Patrick Anderson (1851-1927), chief engineer and superintendent of lighthouses, was born at Levis, Que., and educated at Bishops College, Lennoxville, and Manitoba College, Winnipeg. In 1874 he entered the civil service as a draughtsman in the Department of Marine and Fisheries, Ottawa, soon becoming assistant engineer, and in 1880 was appointed to the post which he held until his retirement in 1919. Colonel Anderson took an active interest in military matters, serving in the Canadian Militia during the Fenian Raids, and later commanding the 43rd Regiment. He was one of the first members of the Canadian Society of Civil Engineers and assisted in its organization, being appointed to Council in 1890, 1891 and 1901, and a vice-president in 1902. He was created a C.M.G. in 1913.

Colonel William Patrick Anderson, C.M.G.
President, 1904



Ernest Marceau, B.A.Sc.
President, 1905

Ernest Marceau (1852-1919), professor and canal engineer, was born at Danville, Que., and graduated from the Ecole Polytechnique, Montreal, in 1877. During his entire engineering career he was associated with the canals of eastern Canada, and for many years was Superintending Engineer of Canals in the province of Quebec. In 1904 he was appointed head of the Ecole Polytechnique of Montreal, and in 1909 went to Europe on behalf of that institution. Mr. Marceau served on the Council of the Canadian Society of Civil Engineers in 1897, 1898 and 1899; in 1901 was elected vice-president for three years, and in 1909 was appointed Treasurer. He was the recipient of the Gzowski Medal in 1909 for his paper on the Carillon Canal, Dam and Slide.

Hugh David Lumsden (1844-1928), land surveyor and railway engineer, was born at Belhelvie Lodge, Aberdeenshire, and received his early education in Aberdeen and at Wimbledon, coming to Canada in 1861. He served his time as provincial land surveyor at Woodville, Ont., and was admitted to practice in 1866. In 1871 Mr. Lumsden was engaged on the location of the Toronto and Nipissing Railway, and from that time was almost continuously employed in the location or construction of railways. On the commencement of the National Transcontinental Railway in 1904 Mr. Lumsden was appointed chief engineer, and held that position until 1910. He then carried on a consulting practice until 1914. He joined the Canadian Society of Civil Engineers in 1887, and after serving on Council for some years, became a vice-president in 1898.

Hugh David Lumsden
President, 1906

W. McLea Walbank (1856-1909), architect, land surveyor and hydro-electric engineer, attended the engineering course of Queen's University, Ireland, and subsequently that of McGill University, graduating in 1877. He practised as an architect and land surveyor in Montreal for some years, during which time he designed and carried out sewerage works and constructed several factories. One of his most important surveying commissions was the subdivision of the Caughnawaga reserve. He was, however, chiefly known to the engineering world in connection with the construction of the Lachine Land and Hydraulic Power Works, of which he was general manager. When this company sold out its interests to the Montreal Light, Heat and Power Company, he became vice-president and chief engineer of the latter company. One of the original members of the Canadian Society of Civil Engineers, Mr. Walbank served on Council in 1903 and 1904, being elected a vice-president in 1906.

W. McLea Walbank, B.A.Sc.
President, 1907

John Galbraith (1846-1914), educationalist and engineer, was born in Montreal, and graduated from the University of Toronto in 1868. It was through Dr. Galbraith's efforts that the Legislative Assembly sanctioned the establishment of the well-known School of Practical Science at Toronto, and upon its establishment he assumed the responsibility of instruction in engineering. In 1906 this School became the Faculty of Applied Science and Engineering of the University of Toronto, of which Dr. Galbraith was appointed dean. In recognition of his work both Toronto and Queen's Universities conferred upon him the honorary degree of LL.D. He had also a notable career as an engineer, having been engaged on the construction of the Intercolonial Railway and the Midland Railway extension to Sudbury. His extensive knowledge of the geographical and geological nature of the country was acquired by canoe and trail years before other white men had penetrated into the Indian's domain.

George Alphonso Mountain (1860-1927), noted railway engineer, was born at Quebec City, and studied for his profession with the city engineer of Quebec. His early engineering work was with survey parties of the Quebec and Lake St. John Railway, on work at the Quebec graving docks and on the Newfoundland Railway. In 1881 he joined the staff of the Canada Atlantic Railway, as assistant engineer, being appointed chief engineer in 1887, and holding that position until 1904 when he became chief engineer with the Board of Railway Commissioners. For twenty years he held the latter important post, resigning in 1924 on account of ill health. Mr. Mountain was one of the first members of the Canadian Society of Civil Engineers, and served on Council in 1893, 1899, 1900 and 1901. He was a vice-president in 1903 and 1905.

Henry Norlande Ruttan (1848-1925), soldier, railway and municipal engineer, was born at Cobourg, Ont. and during his active engineering career held many important positions with the Grand Trunk, Intercolonial and Canadian Pacific Railways. In 1874 he was engaged on the first surveys for the Canadian Pacific Railway along the north shore of Lake Superior, and during the following two years had charge of the first survey party through the Yellowhead Pass. For a period of twenty-nine years, 1886-1915, he was city engineer for Winnipeg, Man. At the age of sixteen years General Ruttan joined the Cobourg Rifles, was a veteran of the Fenian Raids and the Northwest Rebellion, in 1915 was appointed O.C. at Winnipeg, retiring in 1918. General Ruttan was one of the signatories of the Charter of the Canadian Society of Civil Engineers, a councillor for twelve years, 1887-1906, and in 1909 a vice-president.

Charles Henry Rust (1852-1927), municipal engineer, was born at Great Waltham, Essex, England, and received his education at Brentwood Grammar School, coming to Canada in 1872. He was first engaged on a preliminary survey of the Ontario and Quebec Railway, later entering the service of the city of Toronto. In 1892 Mr. Rust was appointed acting city engineer, then deputy city engineer, and later city engineer and manager of water works at Toronto. In 1912 he resigned to become city engineer of Victoria, B.C., but returned to Toronto six years later to accept a position with the Toronto Street Railways and Toronto Electric Light Company, subsequently the Toronto Hydro-Electric System. His services were frequently in demand as a consultant and expert among the municipalities near Toronto. He served as a councillor of the Society during 1899, 1900, 1905 and 1907, and as a vice-president in 1901 and 1910.

William Francis Tye (1861-1932), railway and consulting engineer, was born at Haysville, Ont., and educated at Ottawa College and the University of Toronto, graduating in 1881. In 1882 he joined the Canadian Pacific Railway, in 1886-1887 was on the location of the St. Paul, Minneapolis and Manitoba Railway, and then spent several years on railway and mining work in Mexico. From 1890-1896 he was with several railways in Western Canada and in 1897 joined the Canadian Pacific Railway as personal engineering assistant to Lord Shaughnessy, becoming chief engineer in 1904, but retiring two years later to engage in consulting work. Mr. Tye was awarded the Gzowski Medal in 1917 for his paper on "Canada's Railway Problem and its Solution." He served on Council and as a vice-president from 1905 to 1910.

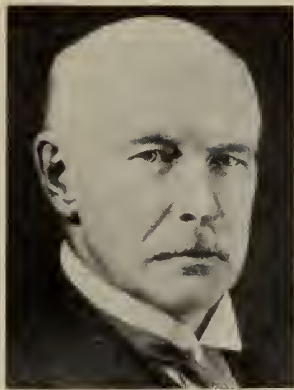
George Alphonso Mountain
President, 1909

Charles Henry Rust
President, 1911

John Galbraith, M.A., LL.D.
President, 1908

Brig.-Gen. Henry N. Ruttan, C.M.G., Hon.M.E.I.C.
President, 1910

William Francis Tye
President, 1912



Phelps Johnson, LL.D.
President, 1913

Francis Clarke Gamble
President, 1915

Phelps Johnson (1849-1926), bridge designer and industrialist, was born at Warwick, N.Y., and began his engineering career at Springfield, where from 1867 until 1878 he was with the R. F. Hawkins Iron Works. He was subsequently with the Wrought Iron Bridge Company at Canton, Ohio, and in 1882 joined the Toronto Bridge Company at Toronto. In 1883 Mr. Johnson was appointed manager and engineer in charge of the Toronto works of the Dominion Bridge Company, succeeding in 1888 to the post of chief engineer at Montreal, becoming managing director, and from 1913-1919 president of the company. From 1911-1920 and during the construction of the Quebec bridge he was also president and general manager of the St. Lawrence Bridge Company. In 1921 the honorary degree of LL.D. was conferred upon him by McGill University. He served on the Council of The Institute on several occasions and as a vice-president in 1907.

Matthew Joseph Butler (1856-1933), railway and consulting engineer, began the study of engineering at the University of Toronto in 1874, and was successively assistant and chief engineer for the Kingston and Pembroke Railway, chief engineer of the Napanee, Tamworth and Quebec Railway, and assistant engineer with the National Transcontinental Railway. In 1885 he conducted a number of surveys for the Ontario government and in 1905 was appointed Deputy Minister of Railways and Canals, becoming chairman of the Board of Management of the Canadian Government Railways in 1909. From 1910 until 1913 he was general manager of the Dominion Iron and Steel Corporation, and later took charge of the Longueuil plant of the Armstrong Whitworth Corporation. He entered private practice as a consulting engineer in 1919. Mr. Butler was a member of Council in 1896, 1897, 1904 and 1905, and a vice-president in 1906 and 1907.

Francis Clarke Gamble (1848-1926), railway and public works engineer, was born in Toronto and attended Upper Canada College, and Rensselaer Polytechnic, Troy, N.Y. He entered the employ of the Intercolonial Railway in 1869, and subsequently the Great Western Railway, the Prince Edward Island Railway, becoming assistant engineer on the Intercolonial Railway in 1876, and in 1880 first assistant engineer with the Canadian Pacific Railway. In 1881 he entered the service of the Department of Public Works, British Columbia, and in 1898 was appointed public works engineer, becoming chief engineer of the Department of Railways for the province in 1910. Mr. Gamble was elected a member of Council in 1892 and again in 1898, and in 1913 and 1914 was a vice-president.

George Herrick Duggan (1862), Chairman of the Board of the Dominion Bridge Company, Limited, and Vice-President of the Royal Bank of Canada, was born in Toronto, and graduated from the University of Toronto in 1883. He was appointed chief engineer of the Dominion Bridge Company in 1891, and subsequently joining the Dominion Coal Company, was promoted to second vice-president and general manager in 1904. In 1910 he returned to the Dominion Bridge Company as chief engineer, being appointed president in 1918, and president and managing director of the Dominion Engineering Works in 1920. In 1920 he received the degree of D.Sc. from the University of Toronto; the honorary degrees of LL.D. from Queen's University in 1919 and from McGill University in 1921. Dr. Duggan served on the Council of The Institute for nine years, was a vice-president for five years, and was the recipient of the Sir John Kennedy Medal in 1931.

John Stoughton Dennis (1856), surveyor, irrigation engineer, and soldier, was born at Weston, Ont., and after securing the degrees of Dominion Land Surveyor and Dominion Topographical Surveyor played an important part in the development of the prairie provinces, rising to the position of Deputy Minister of Public Works, and chief engineer of the Northwest Territories. As land commissioner for the Hudson Bay Company he assisted in developing irrigation in the west; in 1903 he joined the Canadian Pacific Railway and in 1912 became assistant to the president. He was appointed Chief Commissioner of Colonization and Development of that Company in 1917, retiring in 1930. From 1915 to 1917 Colonel Dennis was head of the Canadian Mission in the United States; served on the British-Canadian Mission; in 1918 was chairman of the Siberian Trade Commission and was awarded the C.M.G. and also foreign decorations. He was a member of Council of the Society in 1906 and 1911, and a vice-president in 1907.

Matthew Joseph Butler, C.M.G., LL.D.
President, 1914

George Herrick Duggan, D.Sc., LL.D.
President, 1916

Colonel John Stoughton Dennis, C.M.G.
President, 1917

Henry Hague Vaughan (1868), mechanical and industrial engineer, was born at Forest Hill, England, and educated at King's College, London, afterwards serving three years with Nasmyth, Wilson and Company of Patricroft, England, as an apprentice. He was with a number of railroads in the United States before becoming assistant to the vice-president of the Canadian Pacific Railway, Montreal, in 1905, where he had general charge of the design and construction of locomotives and car equipment, the maintenance of equipment east of Fort William, and the operation of the Angus shops. In 1915 Mr. Vaughan became president of the Montreal Ammunition Company, and subsequently vice-president of the Dominion Copper Products Company. In 1916 he was appointed vice-president of the Dominion Bridge Company, leaving in 1920 to engage in consulting practice. He was a vice-president of the Society in 1910-1912.

Reuben Wells Leonard (1860-1930), railway, hydro-electric and mining engineer, was born at Brantford, Ont., and educated at the Royal Military College, Kingston, obtaining his early engineering experience with the Canadian Pacific Railway. In 1892-1893 he was on the construction of the first hydro-electric power development at Niagara Falls, subsequently becoming chief engineer of two railways, then entering the mining field as engineer for the Lake Superior Corporation. In 1902 Colonel Leonard became engineer of the hydro-electric developments at De Cew falls, then at Kakabeka falls and returned to mining work in 1906 as promoter and president of the Coniagas Mines. He was appointed chairman of the National Transcontinental Railway Commission in 1911, served as a director of a number of companies, was a governor of the University of Toronto and of Queen's University, and in 1916 created the Leonard Foundation, establishing scholarships in schools and colleges of the Dominion. He was one of the original members of the

Henry Hague Vaughan
President, 1918

Colonel Reuben Wells Leonard
President, 1919

Society, served on Council for three years, and was a vice-president in 1910. In 1929 he received the Sir John Kennedy Medal.

Robert Alexander Ross (1865-1936), outstanding mechanical and electrical consulting engineer, was born at Woodstock, Ont. and educated at the University of Toronto, graduating in 1890. He was with the Canadian General Electric Company until 1893, then chief electrical and mechanical engineer of the Royal Electric Company, Montreal. In 1896 he commenced his consulting practice in Montreal, and was responsible for the design of important electrical and power installations. He acted as consultant to many of the larger cities in Canada, and carried out work in China, India, the Straits Settlements, Russia, Finland, Scotland, Australia, the West Indies and the United States. He was a member of the Administrative Commission of Montreal for three years and in 1921 received the honorary degree of D.Sc. (Toronto). Dr. Ross was a member of several famous commissions and boards. He served on Council for eight years, as vice-president from 1914 to 1916 and in 1934 received the Sir John Kennedy Medal.

John Morrice Roger Fairbairn (1873), chief engineer of the Canadian Pacific Railway, was born at Peterborough, Ont., and graduated from

Robert Alexander Ross, E.E., D.Sc.
President, 1920

John Morrice Roger Fairbairn, D.Sc.
President, 1921

the University of Toronto. For some years he was with the Department of the Interior, Department of Railways and Canals, the Department of Militia and Defence, and then for a short time in private practice. Since 1901 he has been associated with the Canadian Pacific Railway, becoming principal assistant engineer in 1910, afterwards engineer, maintenance of way, and later assistant chief engineer. Mr. Fairbairn was appointed to his present position in 1918, and received the degree of D.Sc. from the University of Toronto in 1921. He has served as a member of the Council and a vice-president of The Institute.

John G. Sullivan (1863), railway and canal engineer, was born at Bushnell's Basin, New York, and graduated from Cornell University in 1888. He commenced his engineering work with the Great Northern Railway and came to Canada as assistant engineer for the Alberta Railway and Coal Company in 1893. From 1898 until 1905 he was on railway construction, latterly as division engineer on the Canadian Pacific Railway. From 1905 to 1907 Mr. Sullivan was assistant and acting chief engineer of the Panama canal. In 1908 he became assistant chief engineer for the eastern lines of the Canadian Pacific Railway; in 1911 chief engineer of western lines, and in 1915 chief engineer of the system. He resigned in 1918, but was retained

John G. Sullivan, C.E., LL.D.
President, 1922

Arthur T. St. Laurent, B.A., C.E.
President, 1923

as consulting engineer until 1928. Mr. Sullivan served on the Council of the Society in 1910 and 1918, and was a vice-president in 1911, 1912 and 1913. He is the recipient of the Sir John Kennedy Medal this year.

Arthur T. St. Laurent (1859-1923), public works engineer, was born at Rimouski, Que., and graduated from the Ecole Polytechnique, Montreal, in 1885. Following graduation he was engaged on harbours and railway surveys, then for two years on the Temiscouata Railway construction. In 1888 he joined the engineering branch of the Department of Public Works, and in 1890 was appointed assistant resident engineer at Winnipeg for the district of Manitoba and the Northwest Territories. In 1895 Mr. St. Laurent surveyed the Red river below Winnipeg and prepared the plans and designs of a proposed lock and movable dam. In the same year he was appointed engineer in the department, and became chief engineer in 1922. In 1909 he was a member of Council of the Society, and a vice-president during 1915, 1916 and 1917. Elected President in 1923 he died in March of the same year.

Walter Joseph Francis (1872-1924), consulting engineer, was born in Toronto and graduated from the University of Toronto in 1893. Following graduation he joined the Central Bridge Engineering Company, and

Walter Joseph Francis, B.A.Sc.
President, 1923-1924

Arthur Surveyer, B.A., B.A.Sc., C.E., D.Eng.
President, 1924-1925

subsequently the Department of Railways and Canals. In 1907 he became assistant manager and chief engineer of the Dominion Engineering and Construction Company, Montreal, also engineer to the Royal Commission on the Quebec Bridge disaster. Mr. Francis reported on various hydro-electric power propositions including that of the North Saskatchewan river at Edmonton, also on the public utilities of the city of Edmonton, and the construction of the Don siphon for main sewers, Toronto. In 1910 he formed a partnership with Frederick B. Brown. He was the first chairman of the Montreal Branch and either a councillor or vice-president from 1910 until he became president; he died during his term of office.

Arthur Surveyer (1878), consulting engineer, was born in Montreal and graduated from Laval University and the Ecole Polytechnique. He took a post-graduate course at the Ecole Speciale d'Industrie et des Mines du Hainaut, at Mons, Belgium, then joined the Public Works Department of Canada in 1904, remaining until 1911, when he entered private practice in Montreal. He was a member of the St. Lawrence River Commission, and in 1912 reported to the Federal Government on the effect of the Chicago Drainage Canal diversion. Dr. Surveyer has been employed in a consulting capacity by the Federal Government, the province of Quebec and most of the important cities in the province. He was the recipient of the degree of D.Eng. from the Rensselaer Polytechnic Institute in 1924. He served on Council from 1915 to 1921, and was then elected a vice-president, serving three years.

Major George A. Walkem, B.Sc.
President, 1926

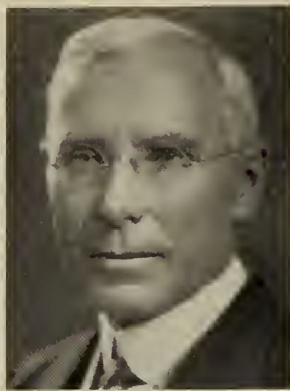
George A. Walkem (1872), managing director of the Vancouver Machinery Depot Limited, Vancouver, was born at Kingston, Ont., and graduated from McGill University in 1896. He served his apprenticeship in the Kingston Locomotive Works and Kingston Foundry; from 1901 to 1905 was works manager for the Vancouver Engineering Works, and in 1906 organized the Vancouver Machinery Depot. He rendered distinguished service during the War, his duties in Egypt and Palestine with the Railway Operation Division, R.E., including the charge of the Kantara Military Railway. Major Walkem is president of the Gulf of Georgia Towing Company and of the British Columbia Dock Company. He takes an active part in civic and public life, served as a Councillor of The Institute during 1921 and 1922, and was a vice-president in 1923 and 1924.

Albert R. Decary (1875), superintendent engineer of the province of Quebec for the Department of Public Works of Canada, was born in Montreal, and received his education at the St. Mary's College and at the Ecole Polytechnique, Montreal. In 1905 he was appointed district engineer at Quebec for the Department of Public Works of Canada, and in 1913 received the appointment which he still holds. Dr. Decary has always taken an active interest in the affairs of The Institute, having been made a councillor in 1914, and sitting on Council in that capacity until 1924, when he became vice-president. He has been a member of a number of special committees of The Institute, and when the Quebec Branch was formed in 1907 was among its principal promoters. In 1927 the degree of D.A.Sc. was conferred on him by the University of Montreal.

Albert R. Decary, D.A.Sc.
President, 1927

Julian Cleveland Smith (1878), President of the Shawinigan Water and Power Company, Montreal, was born at Elmira, N.Y., receiving his early education at Buffalo, and his engineering training at Cornell University, graduating in 1900 with the degree of M.E. He began his career as a draughtsman with Wallace C. Johnston at Niagara Falls, N.Y., and in 1902 joined the Shawinigan Water and Power Company as assistant engineer of their plant at Shawinigan Falls, Que. In 1903 he was appointed superintendent of the plant, and gradually advanced to general superintendent and chief engineer of the company. He became vice-president of the company in 1913, general manager in 1916, and president in 1933. Mr. Smith also presides over the activities of a number of subsidiary and associated companies. The degree of Doctor of Laws was conferred upon him by Queen's University in 1922.

Charles Hamilton Mitchell (1872), hydraulic engineer, soldier and educationalist, was born at Petrolia, Ont., graduating from the University of Toronto in 1892. In 1898 he received the degree of C.E., and the honorary degrees of LL.D. (Toronto) in 1919, and D.Eng. (New York) in 1922. He acted as assistant city engineer, and city engineer of Niagara Falls, N.Y., and from 1901 to 1905 was connected with the Ontario Power Company. In 1906 he travelled through Europe, studying hydro-electric power developments, then entered private consulting practice in Toronto until 1914, engaged largely on the economics and design of hydraulic and hydro-electric power works. He served overseas during the Great War for five years on the General Staff (Intelligence) in France, Belgium, Italy and England, being mentioned in despatches seven times, and receiving numerous British and foreign decorations. General Mitchell was appointed Dean of the Faculty of Applied Science and Engineering of the University of Toronto in 1919. He served on the Council of The



Brig.-Gen. Charles H. Mitchell, C.B., C.M.G., D.S.O., C.E., D.Eng.
President, 1929

Institute during 1908-1909, and as vice-president from 1920 to 1923.

Alexander Joseph Grant (1863), eminent canal engineer, was born in Banffshire, Scotland, and educated at the University of Ottawa and St. Mary's College, Montreal, beginning his professional career in 1880 on a survey for the Canadian Pacific Railway. In 1886 he entered the Department of Railways and Canals, later transferring to the engineering staff of the Soulanges canal. On its completion in 1903 he was appointed engineer in charge of the Port Colborne improvements, remaining there until 1906 when he became superintending engineer of the Trent Canal. From 1919 until he retired in 1934 Mr. Grant was responsible for the construction of the Welland Ship Canal. He assisted in the formation of the Niagara Peninsula Branch in 1919, served on Council as vice-president in 1928-1929 and in 1934 was the recipient of the Sir John Kennedy Medal.

Sam Graham Porter (1875), manager of the Department of Natural Resources of the Canadian Pacific Railway Company, Calgary, was born at Kyle, Texas, graduated from Baylor University, then from the Massachusetts Institute of Technology with the degree of S.B. in 1903. He began his career in the United States Recla-

Sam Graham Porter, S.B., M.A.
President, 1931

mation Service, and after several engineering appointments came to Canada in 1913, entering the Dominion Government service and becoming inspecting engineer in the Irrigation Office of the Department of the Interior at Calgary; later assistant chief engineer and acting commissioner of irrigation. He left the Civil Service in 1918 and joined the Canadian Pacific Railway, becoming superintendent of operation and maintenance of the southern section of the company's irrigation system. Mr. Porter organized the Lethbridge Branch in 1921, served on Council in 1921-1923, and was a vice-president in 1927-1928.

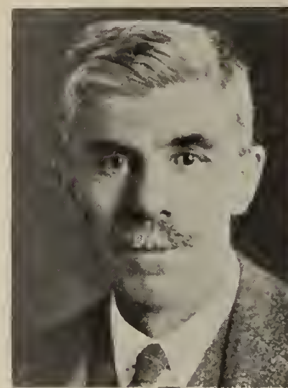
Charles Camsell (1876), geologist, mining engineer and explorer, was born at Fort Liard, N.W.T., and graduated from the University of Manitoba in 1894, later taking post-graduate courses at Queen's University, Harvard University and the Massachusetts Institute of Technology. From 1894 until his appointment as Deputy Minister of Mines in 1920, Dr. Camsell was engaged in the study of geological data and exploration. He has served as chairman of the Dominion Fuel Board, member of the National Research Council, and chairman of the Canadian National Committee of the World Power Conference. His honours include the degrees of LL.D. from Queen's Uni-

Julian Cleveland Smith, M.E., LL.D.
President, 1928

Alexander Joseph Grant
President, 1930

Charles Camsell, B.A., LL.D., F.R.S.C., F.G.S.A.
President, 1932

Olivier Odilon Lefebvre, D.Sc.
President, 1933



Frederick Perry Shearwood
President, 1934

versity and the University of Alberta; his achievements as an explorer in Northern Canada merited the award of the Murchison Grant by the Royal Geographical Society; in 1931 the Institution of Mining and Metallurgy, London, presented him with its gold medal, and he was president of the Royal Society of Canada in 1930. Dr. Camsell was a member of the Council of The Institute in 1929 and 1930.

Olivier Odilon Lefebvre (1879), electrical and hydraulic engineer, was born in Bagot County, Que., and educated at the Ecole Polytechnique, Montreal, graduating in 1902. Entering the laboratories of the Department of Public Works, he afterwards became assistant to the Ottawa district engineer, and in 1912 was sent to Vancouver to survey Burrard Inlet and False Creek. He next became chief engineer of the Quebec Streams Commission, which office he retained until 1935 when he was appointed vice-chairman of the Quebec Electricity Commission. Dr. Lefebvre was responsible for projects such as the Gouin dam, the Lake Kenogami dam and the Mercier reservoir, all being designed and constructed under his supervision. In 1929 he received the Honorary Degree of Doctor of Science from the University of Montreal.

Frederick Perry Shearwood (1866), chief engineer of the Dominion Bridge Company, was born in London, England, and received his education by private tuition, proceeding in 1884 to Brazil, where he entered the service of the Sao Paulo Railway. After three years he came to Canada, and starting as a junior in the engineering department of the Dominion Bridge Company subsequently held the appointments of designing engineer and assistant chief engineer, until in 1921 he received his present appointment. A list of the important structures for whose design or erection Mr. Shearwood has been largely responsible, would be a list of the important work carried out by this company during the last thirty years. He served on Council in 1909 and in 1921-1922, as a vice-president and chairman of the Finance Committee in 1923-1925, and in 1926 as Treasurer.

Frederick Arthur Gaby (1878), hydro-electric and industrial engineer, was born at Richmond Hill, Ont., and graduated from the University of Toronto in 1903. First employed with the Canadian General Electric Co. and the Toronto-Niagara Co., he then went to the City of Winnipeg power plant at Pointe du Bois. In 1907 Dr. Gaby joined the Hydro-Electric Power Commission of Ontario, becoming chief engineer of the Commission in 1912 and later acting as chief executive officer. In 1934 he became consulting engineer with Noranda Mines Limited, then assistant to the president of the Canadian Pacific Railway Company, and is now executive vice-president of the British American Oil Company. He received the degree of D.Sc. from the University of Toronto in 1924 and is a member of many national and international societies.

Ernest Albert Cleveland (1874), Chief Commissioner of the Greater Vancouver Water District and Chairman of the Vancouver and Districts Joint Sewerage and Drainage Board, was born in New Brunswick. He became an articled pupil with Williams Brothers and Dawson in British Columbia, and in 1896 received his commissions as British Columbia Land Surveyor and Dominion Land Surveyor. He devoted some time to engineering study in Seattle and at the University of Washington, and in 1904 commenced private practice, subsequently becoming Comptroller of Water Rights for the Province of British Columbia, and consulting engineer to the Department of Lands. In 1926 he was appointed to the offices he now holds. He received the degree of LL.D. from the University of British Columbia in 1936. Dr. Cleveland was a member of The Institute Council in 1927, and chairman of the local advisory committee for The Institute's Western Professional Meeting in Vancouver in 1934.

Frederick Arthur Gaby, D.Sc.
President, 1935

Ernest Albert Cleveland, LL.D.
President, 1936

## Sir John Kennedy Medallists

1928 Colonel Reuben Wells Leonard, M.E.I.C.
1930 George Herrick Duggan, D.Sc., LL.D., M.E.I.C.
1933 Alexander Joseph Grant, M.E.I.C.
1934 Robert Alexander Ross, D.Sc., M.E.I.C.
1935 Andrew H. Harkness, M.E.I.C.
1936 John G. Sullivan, LL.D., M.E.I.C.

## Honorary Members

| Date of election | | |
|---|---|---|
| * 1889 May | 23 | Sir Frederick Joseph Bramwell, D.C.L., F.R.S. |
| * 1889 Jan. | 3 | Sir John William Dawson |
| * 1889 Jan. | 3 | The Right Hon. the Earl of Derby, G.C.B. |
| * 1889 Nov. | 14 | Sir John Fowler |
| * 1889 Mar. | 28 | Sir Charles Augustus Hartley, K.C.M.G. |
| * 1889 Nov. | 14 | Sir John Hawkshaw |
| * 1889 May | 23 | The Right Hon. Lord Kelvin, F.R.SS. L. & E., LL.D. |
| * 1894 Jan. | 4 | The Right Hon. the Earl of Aberdeen, P.C., LL.D. |
| * 1896 Jan. | 9 | Sir W. C. Macdonald |
| * 1899 Nov. | 23 | The Right Hon. the Earl of Minto, G.C.M.G. |
| * 1900 Apr. | 26 | Lord Strathcona and Mount Royal, G.C.M.G. |
| * 1903 Oct. | 8 | Lt.-Col. Sir Percy C. Girouard |
| * 1903 Oct. | 8 | Thomas C. Keefer, C.M.G. |
| * 1905 May | 11 | The Right Hon. Earl Grey, G.C.M.G. |
| * 1907 Feb. | 7 | Sir Benjamin Baker, LL.D., K.C.B., K.C.M.G. |
| * 1907 Feb. | 7 | Octave Chanute, D.Eng. |
| * 1907 Feb. | 7 | Sir William H. White, K.C.B., F.R.S. |
| * 1907 Oct. | 24 | Sir John Kennedy |
| * 1908 Oct. | 8 | Sir Sandford Fleming |
| * 1909 Oct. | 9 | Collingwood Schreiber, C.M.G. |
| 1912 Jan. | 13 | His Royal Highness the Duke of Connaught and Strathearn. P.C., K.G., G.B.E. |
| * 1917 Oct. | 23 | W. H. Ellis, M.A., M.B., LL.D. |
| 1917 Oct. | 23 | Frank D. Adams, Ph.D., D.Sc., F.R.S.A., F.R.S. |
| * 1917 Nov. | 27 | Lord Shaughnessy, K.C.V.O. |
| 1917 Mar. | 20 | His Grace the Duke of Devonshire, K.G., G.C.M.G. |
| 1919 Sept. | 20 | His Royal Highness the Duke of Windsor, K.G. |
| * 1920 Oct. | 26 | Brig-Gen. Henry Norlande Ruttan, C.M.G. |
| 1922 Jan. | 10 | Arthur L. Clark, B.Sc., Ph.D. |
| * 1922 Jan. | 10 | General Lord Byng of Vimy, G.C.B., G.C.M.G., M.V.O. |
| * 1922 Oct. | 24 | Edouard G. Deville, LL.D., D.L.S. |
| * 1922 Nov. | 21 | C. E. W. Dodwell, B.A., C.E. |
| 1927 Mar. | 15 | The Right Hon. the Marquess of Willingdon, P.C., G.C.S.I., G.C.M.G., G.C.I.E., G.B.E. |
| 1931 June | 16 | The Right Hon. the Earl of Bessborough, P.C., G.C.M.G. |
| 1936 Jan. | 24 | The Right Hon. Lord Tweedsmuir, P.C., G.C.M.G., C.H. |
| 1936 Apr. | 3 | George J. Desbarats, C.M.G. |
| 1937 Apr. | 30 | Robert William Angus |
| 1937 Apr. | 30 | George H. Duggan, LL.D., D.Sc. |
| 1937 Apr. | 30 | Harrison P. Eddy, D.Eng. |
| 1937 Apr. | 30 | Sir Alexander Gibb, G.B.E., C.B. |
| 1937 Apr. | 30 | The Hon. C. D. Howe |
| 1937 Apr. | 30 | Samuel James Hungerford |
| 1937 Apr. | 30 | Jacques Rabut |
| 1937 Apr. | 30 | The Hon. Grote Stirling |

*Deceased.

# THE SEMICENTENNIAL PAPERS

## FIFTY YEARS OF CANADIAN ACHIEVEMENT IN ENGINEERING AND INDUSTRY



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IN PLANNING the Semicentennial Celebrations of the Engineering Institute of Canada it was felt that the occasion might well be marked by a series of articles by members of the Institute, each dealing with the work accomplished in some one branch of engineering or industrial activity in Canada during the period which has seen the Institute's development.

The seventeen papers which follow have been written with the view of carrying out this idea. The Semicentennial Committee desires to express gratitude to the authors who have so generously responded to the committee's request and have given so freely of their time and energy in the preparation of these papers.

Besides their value as a record of achievement, the articles illustrate forcibly the many sided character of the engineer's work in Canada. Collectively they also give a general picture of the remarkable technical developments, which, during the past fifty years, have accompanied Canada's progress towards maturity as a nation.

VIAU BRIDGE, over the River des Prairies, Montreal, Que., opened November 1st, 1930. Total length 1,600 feet and width 57 feet; length of main arches: two 202 feet, two 212 feet, and one 222 feet; total length of approaches 550 feet.

# Public Works

## Under the Department of Public Works, Ottawa

*K. M. Cameron, M.E.I.C.,*
*Chief Engineer, Department of Public Works, Ottawa, Ont.*

Under the Union in 1841 of the provinces of Upper and Lower Canada the public works were carried on by Commissioners of Public Works who had charge of the canals, the works in navigable waters, the harbours, the lighthouses, beacons and buoys, the slides and booms, the roads and bridges, the public buildings and the provincial vessels. Prior to the Confederation of the provinces of Ontario, Quebec, New Brunswick and Nova Scotia in 1867, this body had disbursed on these public works some twenty million dollars.

The River St. Lawrence was usable for the largest vessels then afloat up to Quebec, but beyond that the draft of vessels was limited to 10 to 12 ft. Immediately after the union of Upper and Lower Canada, D. Thompson, civil engineer, was commissioned to examine the channel and following his report favouring a 16-ft. channel, work was commenced in 1844. Later, operations continued under the Harbour Commissioners of Montreal, the project of a 20-ft. channel being completed in 1865.

Prior to the Union in 1841, and from the Union to Confederation in 1867, the provinces had necessarily supplemented the original transportation routes, which were by the waterways, with roads to serve the needs for more rapid means of travel and communication.

The Confederation pact gave the roads, except military roads, and bridges to the provinces, and Dominion Government expenditures thereon since then have been as subsidy for road purposes paid to the provinces.

On the first day of July, 1867, the "British North America Act" came into force. An "Act Respecting the Public Works of Canada," 31 Vict., Chap. 12, was passed on December 21st, 1867, and the Public Works Department came into being, under the direction of the Minister, the Honourable William McDougall.

In addition to continuing the administration of the works which had been under the charge of the Commissioners of Public Works of the United Provinces, there were added to his care the canals, the works in navigable rivers, and the railways of the provinces of Nova Scotia and New Brunswick. The construction of lighthouses was continued under the Department of Public Works but the management of these, as of the provincial vessels, was transferred to the Department of Marine and Fisheries. The greater part of the roads and bridges and certain public buildings was transferred to the local governments, but the construction of military and interprovincial highways, and of classes of public buildings appropriate to the dominion service was reserved to the Dominion, and administered by the Public Works Department. The main additional responsibilities added were the Nova Scotia and the New Brunswick railways.

Fig. 1—The Parliament Buildings, Ottawa.

Over the period of twelve years following Confederation in 1867, several undertakings of note were accomplished. The Intercolonial Railway was constructed and opened to traffic on July 1st, 1876; the Prince Edward Island Railway was completed and opened to traffic on July 1st, 1875, and as a result of the surveys carried out of the route of a railway to be built on Canadian territory and terminating at the Pacific ocean, construction was begun in 1875 of what is now known as the Canadian Pacific Railway.

When in 1879 the Department of Public Works was divided into two departments, to the new Department of Railways and Canals were transferred the railway and the canal activities of the Department of Public Works, and under the continuing Public Works Department were the public buildings, the ports, harbours, piers, dredging, slides and booms, telegraphs, and military and interprovincial roads.

During this period, the channel of the River St. Lawrence to Montreal, which had been deepened to 20 ft. at low water with a width of 300 ft., was further improved. The Minister of Public Works entrusted this work to the Harbour Commissioners of Montreal, constituted in 1830. That body continued the deepening to 25 ft., under their chief engineer, the late Sir John Kennedy.

At Quebec, two works of major importance were carried out under the immediate direction of the Harbour Commissioners, reporting to the Minister of Public Works. The Lorne graving dock at Levis, 500 ft. long and with a depth of 25.5 ft. was constructed, funds being found by grants from the Dominion and Imperial Governments supplemented by an amount raised by the Harbour Commission. The Princess Louise wet dock and tidal harbour, at the junction of the River St. Charles and the St. Lawrence, had been decided on in 1874, and by 1882 the works enclosing the basins had largely been completed.

Noteworthy in their way are the reports by Sandford Fleming, engineer-in-chief, Canadian Pacific Railway, to the Minister of Public Works under date of April 5th, 1879; of James B. Eads, consulting engineer, of Mississippi river fame, to the Minister on Toronto Harbour, under date of March 4th, 1882; and that of the Montreal Flood Commission in 1888.[1]

The early development of the western provinces in 1882 may be judged from the extent of work carried out to that date. The Assiniboine river had been improved for navigation by the removal of boulders and the construction of wing dams, and similarly, the Red river from the United States Boundary to Lake Winnipeg.

In British Columbia, admitted to Confederation in 1871, there was undertaken the construction of a graving dock at Esquimalt, very similar to that constructed at Levis. Harbour improvements in that province up to 1882 were confined to the Skeena, the Naas, the Cowichan, the Courtenay and the Fraser rivers, and to Victoria harbour.

At the close of 1888 the project of deepening the ship channel to Montreal to 27½ ft. had been completed. At that juncture the responsibility for the channel was assumed by the Dominion from the Montreal Harbour Commissioners and successive steps in its further improvement were under the Public Works Department, under which the 27½-ft. channel was maintained as to depth, widened and straightened. In 1899 the project of a 29-ft. depth of channel, 400 to 500 ft. wide, was commenced. This had resulted from the low water years of 1895 and 1897 establishing that the 27½-ft. channel had a dependable depth of only 25 ft. 10 in. At the end of the century considerable attention was being given by the Department to the question of ice breaking in the channel.

The graving dock at Kingston, on Lake Ontario, was completed for operation in 1891, providing a repair facility for the increasing number of vessels trading from the Welland canal through Lake Ontario and the St. Lawrence river and its canal system to Montreal.

The discovery of gold in Yukon territory was followed by a rush of people to that country, and the late Louis Coste, then chief engineer, was sent by the Department, in March, 1898, to study the best means of improving the water courses of the district. Navigation by the water route from White Horse to Dawson City was the only (and still remains the principal) means of access.

The years immediately following were spent in effecting improvements to the route, and in the construction of lines of telegraphic communication with the outside, both of which activities still continue.

[1]Department of Public Works report 1889-90.

### The Twentieth Century

At the beginning of the century it is recorded that over eight hundred works of harbours and rivers, and nearly two hundred and fifty buildings were under direction of the Department; in addition there were 3,666 miles of telegraph land lines and 208 miles of submarine cables, with one hundred and eighty-five offices handling 76,410 messages in a year.

In the Maritime provinces the requirements of navigation for terminal facilities at the major ports were a function of the railways, principally the Intercolonial, the activities of the Department being devoted to the smaller ports, which, however, are of great importance to the population and the industries of that region.

While a similar expansion in the provision of small port facilities on the St. Lawrence and its main tributaries in Quebec was proceeding, the major activities were the completion of the newly adopted depth of 30 ft. at 1897 low water, and 450 ft. width for the channel to Montreal, and the hydrographic survey associated with that waterway.

The eastward movement of the western grain crop had become of moment, elevators being erected at Goderich on Lake Huron, Collingwood, Meaford, Midland and Depot Harbour on Georgian Bay, and at Coteau Landing on the St. Lawrence. These, built by private interests, had necessitated the deepening of the harbours to 20 ft., and the extension of the harbour works. Increased harbour area at Port Colborne, the Lake Erie end of the Welland canal was provided by the construction of a breakwater to enclose a sheltered area of some 438 acres.

The importance of lumbering and fishing on Lake Winnipeg resulted in the construction of harbours at Hnausa and Gimli; and plans were in preparation for the dam at St. Andrews rapids to bring navigation to Winnipeg on the Red river.

The Columbia and the Kootenay rivers were in demand as routes into the interior of Southern British Columbia, where settlement and mining development were active, and works were carried out to facilitate this commerce.

The Fraser river had from early days provided the route into the interior from the coast, and the Royal Engineers had been the first to plan and execute improvements, not only to the river channel but by the construction of the famous Cariboo Trail. The lower reach of the river, from the Gulf of Georgia to New Westminster had been

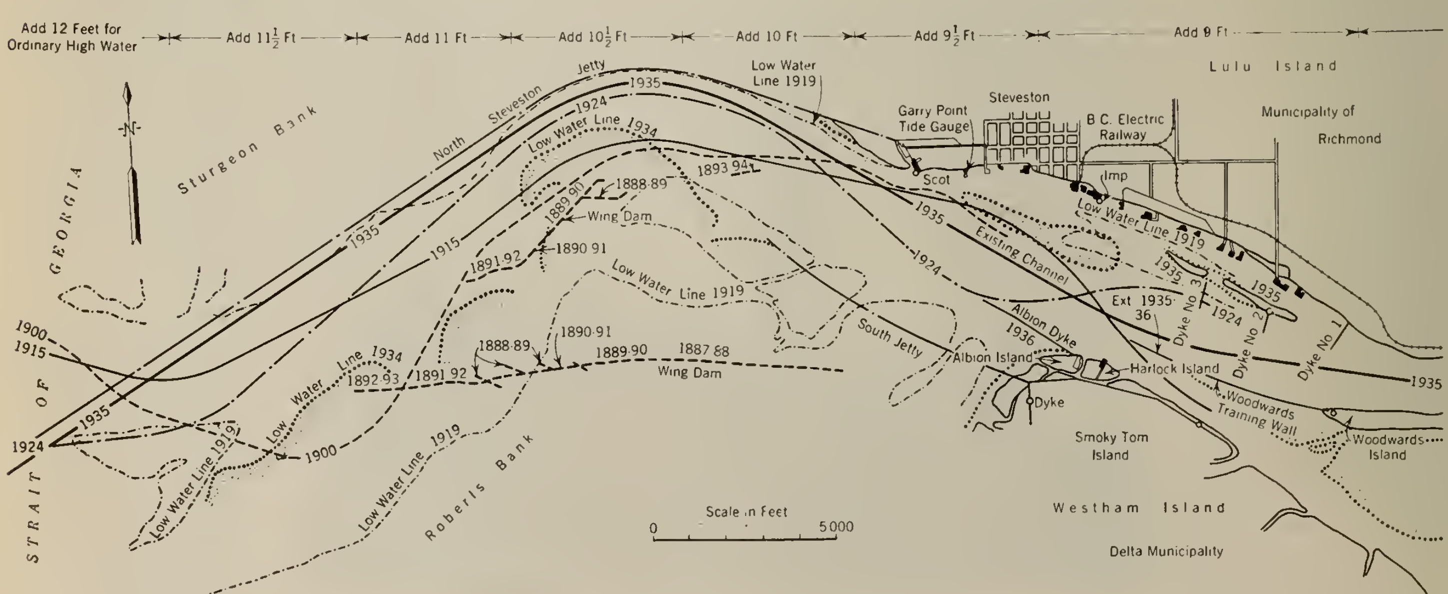



Fig. 2—The Sandheads, Fraser River, B.C.

used with difficulty by ocean vessels, and these difficulties were more pronounced as the size of ships increased with expanding trade.

This development of a stable channel in a river subject to heavy variation in flow, and meandering across some five miles of tidal flats subject to the action of an ordinary tidal range of 12 ft., has been difficult. After several unsuccessful attempts at stabilizing the channel, two reaction jetties were proposed, in 1910, springing from the mainland and extending seawards to the edge of the bank of the delta. A commencement on the north jetty was made, but for some years after the first section was built divided opinion on the future course hampered progress. Later, a plan was developed by a Board of Engineers in the Department's service, who brought to the task their experience of similar though lesser problems of like nature. Valuable geological studies were made by W. A. Johnston,* of the Geological Survey of Canada.

The work on the Fraser estuary has since then followed the plan then adopted, and a channel stable in depth and direction has resulted. As will be seen from Fig. 2, the north jetty is 25,800 ft. or 4.88 miles long, and so far, as practically a single reaction jetty, has functioned with satisfactory results. This is cited as the outstanding instance of this type of problem in Canada.

In the opening decade of the century, with a remarkable increase in population, the definite establishment of the west high among the world's producers of grain, the development of manufacturing in Canada, and the confidence in Canada's future so substantially expressed by the inflow of capital from Great Britain, an added impetus was given to the provision of adequate public works to take care of the situation.

The western railway field was served by the Canadian Pacific from 1885, but its virtual monopoly of transportation of that area was invaded by the construction of the Grand Trunk Pacific from Lake Superior to the Pacific ocean. The National Transcontinental, as a rail route to facilitate the development of Northern Ontario and Quebec and give access to a winter port on Canada's Atlantic seaboard, and the Canadian Northern, virtually a third transcontinental line, were also constructed.

The development of the Lakehead harbours on Lake Superior at Fort William and Port Arthur for transshipment of eastbound grain and reception and dispatch of westbound coal, iron, ore and manufactured products, and of the harbour of Saint John, N.B., as a winter port were the natural outcome of the railway expansion.

### Saskatchewan and Red Rivers

Notwithstanding the expansion of rail facilities in the prairie provinces, the great use and convenience the waterways had been in opening up that area led to an examination being made of the possibility of utilizing the Saskatchewan river, Lake Winnipeg and the Red river as a route for the economical handling of freight. Very complete surveys of the route from Lake Winnipeg to Edmonton, covering a distance of 941 miles, carried out from 1910 to 1915 under the Public Works Department did not indicate that the desired results could be obtained, and the project, so far as the Saskatchewan river is concerned, has remained in abeyance.

The Red river-Lake Winnipeg route into the North was however improved by the construction in 1910 of a curtain dam of the Caméré type at St. Andrews, which raises the level of the Red river by about 20 ft. at its location, some 20 miles downstream or north of Winnipeg, and by about 6 ft. at Winnipeg. It is the first of the kind to be constructed on either of the American continents, and the type was chosen so that the permanent obstruction to the flow of ice and water would be a minimum. A navigation lock permits the passage of vessels past the dam, and the supporting structure of the movable dam carries a highway floor.[2]

*His results are to be found in Memoirs 125 and 135 of the Geological Survey of Canada.

### The Georgian Bay Ship Canal

The route from Montreal to the west from earliest days followed the Ottawa river and the Mattawa to the height of land, and then Lake Nipissing and the French river to Georgian Bay. As commercial development progressed the possibilities of this as an all Canadian route for water transportation were canvassed, and several proposals were considered during the period from 1857 to 1900.[3]

The Government, in 1904, charged the Minister of Public Works with the carrying out of an examination of the route, the survey to be of such a character "that there could be projected on the plans the best location possible for a canal at least 22 ft. in depth, with a bottom width of 300 ft., from which profiles could be drawn and a correct estimate made of the amount and character of material in excavation and embankment, nature of various foundations, and final design of locks, dams, regulating works and other structures; also the right of way and definition of flooded areas."[4]

The surveys and examinations, designs, calculations and all pertinent engineering studies were under the direction of the late Arthur St. Laurent, past president of The Engineering Institute of Canada, as engineer in charge, reporting to the chief engineer of the Department, with C. R. Coutlee and S. J. Chapleau as district engineers.

The extent of the project may be gauged from the fact that the length of the route investigated, from Bout de l'Ile, at the foot of Montreal island, to the western end, the mouth of the French river at Georgian Bay, is 451 miles.

The report of the Board of Engineers, dated January 20th, 1909, advised the Minister of Public Works that a 22-ft. waterway for the largest lake boats (600 ft. by 60 ft. by 20 ft. draft) could be established for $100,000,000, with an annual maintenance cost of $900,000. It submitted plans for a canal with 27 locks varying from 5 ft. to 50 ft. lift, connecting 23 navigable pools of various lengths; the locks to be 650 ft. long, 65 ft. wide, and 22 ft. deep.

The project has not been carried out, the Government in 1912 deciding to proceed with the Welland ship canal for deep draft vessels, that work being opened to traffic in 1930.

The Georgian Bay ship canal survey, however, resulted in a very complete knowledge of the water power resources of the Ottawa river and its principal tributaries being obtained, the computed amount of power available being 1,000,000 horsepower.

### Ottawa River Storage

At the Chaudiere falls section of the Ottawa river, between Ottawa and Hull, water power leases had been granted under the Government of Canada prior to Confederation; at Confederation these fell to the lot of the Dominion to administer. In subsequent years difficulties arose over apportionment of the water available; to clarify the situation it was arranged that the lessees would build a compensating dam above the Chaudiere falls, and that the Government would construct storage and regulating dams, at the foot of Lake Timiskaming, at the foot of Quinze lake, both on the upper Ottawa, and at the outlets of Kipawa lake.[5]

On the Georgian Bay slope Lake Nipissing drains out

[2]Engineering Record, March 26th, 1910.
Engineering News, October 6th, 1910.
[3]Appendix 70, Public Works report 1867-1882.
[4]Georgian Bay Ship Canal Survey report, 1909.
[5]Ottawa River Storage report, Sessional Paper 19a, of 1911; 19 of 1912; and 19 of 1913.

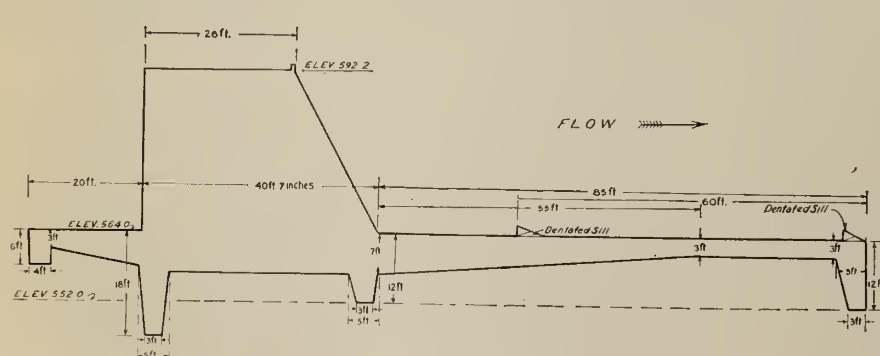
through the French river, and to benefit navigation, at the same time to do away with the annual cost of dredging in channels and at wharves, dams with Stoney sluices were constructed at the Chaudiere rapids, in the main outlet, and dams with stoplogs in the other, the outlet of the lake into the French river. The regulation of Lake Nipissing in this manner was an integral part of the Georgian Bay ship canal proposal above referred to.

The foundation conditions at the only available site for the regulating dam at the foot of Lake Timiskaming were bad, the river there following a deep cleft in the country rock, probably a fault, which had been filled with boulders of great size, and sand. Considering the class of equipment then available for construction, and the comparative inaccessibility of the site, the dam as then built, of stop log sluices on a wide concrete foundation and founded on material of the nature mentioned, was a credit to its builders. Subsequently the action of the discharge at high flows, which reaches 110,000 c.f.s., scoured out the foundation on which the concrete mattress had been laid, and in 1931 it became necessary to reconstruct the Quebec channel dam. A section of the dam as reconstructed is shown in Fig. 3; it incorporates the patented "dentated sills" of Dr. Rehbock, to overcome the scouring action, has a much heavier section, and is functioning satisfactorily.

An unexpected situation developed during the building of the Quinze and the Kipawa lake dams. Concrete was used in their construction, and all usual precautions were used to check the aggregates. When the works were nearly completed it was seen that the concrete had not developed the strength expected, and examination showed the cause to be the presence of a transparent coating of organic matter on the particles of the aggregate used. This is insoluble in water, cannot be detected by the eye, but can be removed by a 3 per cent solution of commercial caustic soda. Its presence is to be suspected in deposits of a siliceous nature, but will not be found where lime is present. That part of the structure built with aggregates so treated is sound, but the greater part built before the trouble was detected has given trouble from disintegration, and the Quinze dam will require replacement from this cause very shortly. As far as known to the author, this circumstance had not previously been experienced elsewhere.

### The Grain Export Trade

The grain trade of Canada has played an outstanding part in the development of the country. The movement of this important bulk commodity from the west has been largely by water and the provision of the necessary facilities has largely devolved on the Department of Public Works.



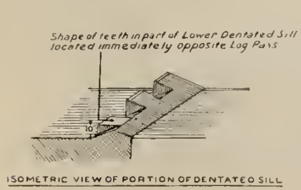




**Fig. 3—Cross Section of Dam, Temiskaming, Que.**

At Kingston, at the foot of Lake Ontario, the cargoes of lake steamers, limited in draft to 14 ft. by the Welland canal, used to be transferred to a barge fleet for passage to Montreal. In later years canal-size steamers went through to Montreal; since the completion of the Welland ship canal, upper lake freighters have access to Lake Ontario, and Kingston has again become, with Port Colborne, Buffalo and Prescott, an important grain transfer point.

The first shipment of grain from the Lakehead was in 1883. Ten thousand bushels were shipped on the steam barge *Erin*, the grain being loaded by wheelbarrows and horse carts. The schooner *Sligo*, in 1884, carried the first cargo of grain handled through a Lakehead elevator.

The elevator storage capacity at Port Arthur and Fort William has grown from one elevator of 350,000 bushels capacity in 1884, to 30 elevators in 1937, with a total capacity of 92,680,000 bushels. The grain shipped at the Lakehead during the navigation season of 1936 was 137,185,000 bushels.

## CANADIAN HARBOURS

### The Lakehead Harbours

The development of the harbours of Port Arthur and Fort William is indicated by Fig. 4. At Port Arthur the harbour has been reclaimed from the open lake by the construction of breakwaters, with the harbour area improved for ships by dredging the sheltered area thus created.[6] At Fort William, the development has followed the water course of the Kaministiquia river, which together with its branch outlet, the "Mission," have been widened to 600 ft. and deepened to 25 ft. The "McKellar" outlet has been similarly widened and deepened but the improvement extends to the outlet only, and not into the lake.

In the development to date some 49,000,000 cubic yards have been moved by dredging at prices prevailing from 9 cents per cubic yard, scow measurement, in 1907, to about 18 cents per cubic yard, situ measurement, recently; and in the rubble mound breakwater extending southwards 12,700 ft. from Bare Point at Port Arthur some 3,023,376 tons of rock have been placed as the work has progressed from 1911 to date.

### The Pacific Outlet

The first, experimental, shipment of 100,000 bushels of grain from Vancouver to Europe in 1917 demonstrating the feasibility of the Panama canal route for grain shipments, has led to increasing amounts being forwarded, and to the establishment of elevator and other facilities at Vancouver, New Westminster and Prince Rupert.

Vancouver has now a combined elevator storage capacity of 17,843,000 bushels, and shipments reached 96,869,841 bushels of all grains, in the 1932-1933 crop year.

### The Atlantic Winter Outlet

With the completion of the National Transcontinental Railway, the desire for Canadian winter ports on the Atlantic seaboard was met, in part, by the construction, under the Government Railways, of the ocean terminals at Halifax. The existence and suitability of St. John, N.B., as a winter port was recognized in the undertaking of extensive deep water piers, improvement of the entrance channel by dredging, and the construction of a graving dock, capable of accommodating the largest ships then in existence or contemplated. The wharves then existing at

[6] Breakwater Construction in Port Arthur Harbour, by F. Y. Harcourt, M.E.I.C., in The Engineering Journal, April, 1931.

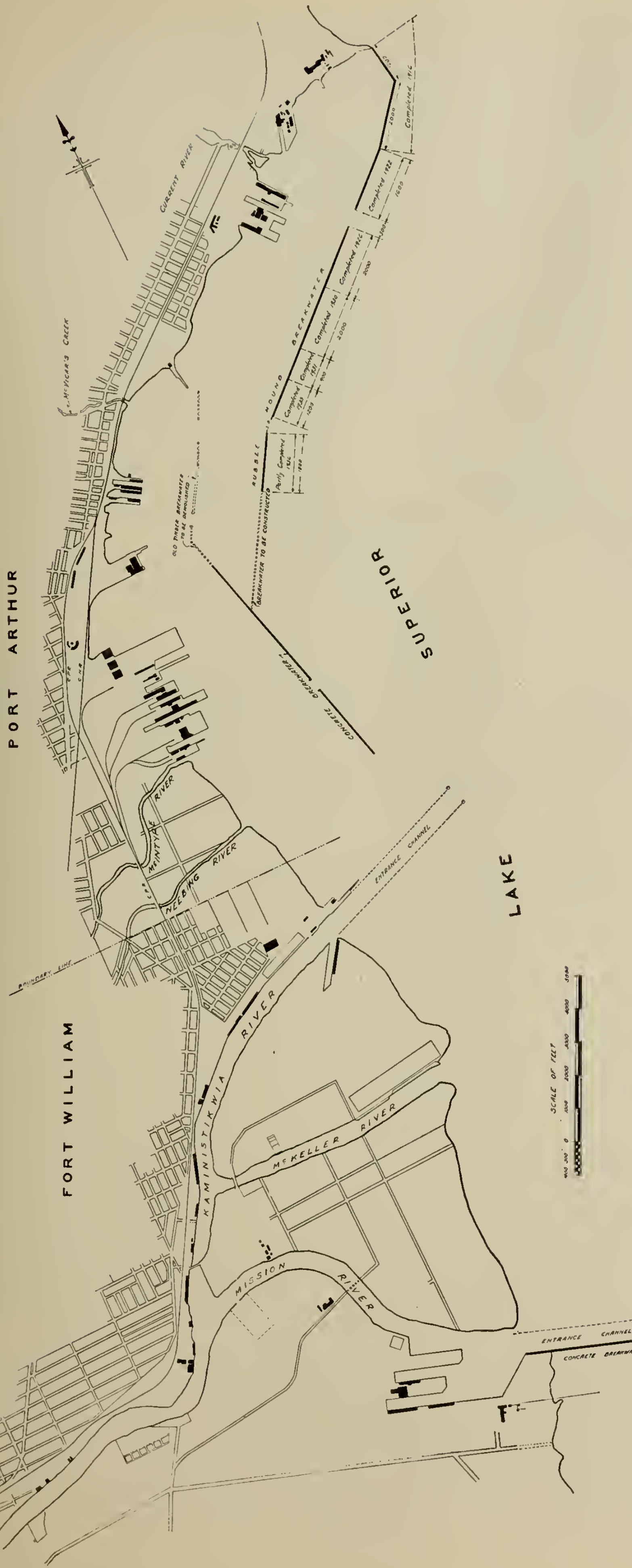



Fig. 4—Harbour at Fort William and Port Arthur, Ont., 1937.

St. John were for the greater part the property of the city, the Intercolonial Railways having provided one structure. This programme was carried out under the Department of Public Works, and, until the formation of the St. John Harbour Commission, in 1928, all Dominion Government commitments in that harbour were entrusted to the Department.

### Vancouver

On the Pacific coast the port of Vancouver served as Canada's sole outlet of major importance until the terminus of the Grand Trunk Pacific Railway was established at Prince Rupert. The importance of fostering trade with the Orient was recognized by the Government undertaking the improvement, by dredging, of the entrance to Vancouver. A large bucket ladder dredge was built in Scotland, and was employed from 1910 to 1918, in deepening to 35 ft. at low tide, from a natural controlling depth of 30 ft., and in widening to 1,200 ft. the channel entrance to the harbour; in this operation some 4,100,000 cubic yards were removed. The Department also carried out the construction of the Lapointe pier, a timber-crib structure[7] protected against the ravages of marine insects by a reinforced concrete sheathing, 18 in. thick.

### Victoria

The port of Victoria, being a port of call for the trans-Pacific liners, as well as for other ocean vessels, had been one of the earliest ports to be improved, the colonial government having commenced its development prior to the entry of the province into Confederation. The Dominion continued the improvement, which for many years consisted in deepening the harbour by dredging. To extend the deep water wharf accommodation, all of which was privately owned, the Department, in the period 1913 to 1916, constructed a rubble mound breakwater as a protection to vessels lying at the Ogden Point deep water piers, also undertaken by the Department, now the site of the grain elevator at that port, and operated by the Canadian National Railways.

### Montreal, and the Ship Channel

The improvement of the St. Lawrence River ship channel continued under the Department of Public Works until 1904, when those activities were transferred to the Marine Department, now the Department of Transport. During this period the Department constructed the Jacques-Cartier pier, completed in 1906, and a grain elevator, with wharf at section 15.

The problems of meeting the requirements for transportation facilities in Canada were very pressing; a Royal Commission on Transportation was created in 1902, and submitted its Report to the Minister in 1904-05.[8] The report presents a picture of conditions as at that time, and reflects the trend of thought on this important subject.

[7]Described by W. G. Swan in another paper of this series.

[8]Report of Royal Commission on Transportation, Sessional Paper No. 19a.


Fig. 5—Harbour at Toronto, Ont. (Heavy lines indicate work done by Public Works Dept.)

### Quebec

In Quebec harbour development of shipping requirements was met by the construction of a wharf at Pointe à Carcy, 1,460 ft. long, with an available depth of 42 ft. at low tide. This work, commenced in 1902, was carried out in five sections and completed in 1911.

### Three Rivers

The increasing importance of Three Rivers as a manufacturing centre, and as a point for trans-shipment to and from the St. Maurice valley, was met by the construction, completed in 1907, of a wharf on the St. Lawrence river with a length of 1,968 ft., and a depth at low water to accommodate ocean vessels.

The extensive territory in Quebec, south of the St. Lawrence river and dependent on Quebec harbour as a point of transfer between ship and shore was accommodated by a deep water wharf, 903 ft. long; the needs of the territory have now outgrown the capacity of the wharf and a further deep water wharf is presently under construction by the Department.

### Toronto

The industrial possibilities of Toronto harbour being recognized by the city, a scheme for improvement of the eastern portion to provide sites for industrial purposes was drawn up. Provision was made, when the Department reconstructed the western entrance to this harbour, in 1908 to 1912, that ample depth could be made available for larger ships. This was done in 1929, to coincide with the opening of the Welland ship canal, a depth of 27 ft. being provided.

Following the reconstitution of the Toronto Harbour Commission the city undertook and has carried out under that body an effective scheme of harbour improvement, the Commission developing a very complete system of wharfage on the harbour. The Dominion Government, under the Department of Public Works undertook to develop the eastern or Ashbridges Bay section of the harbour by the construction of a wharfage system, and dredging. Work continued from 1912 to 1926, and involved the building of some 16,705 lineal feet of revetment bordering a ship channel and turning basin and providing a large area with the advantages of both rail and water transportation. The Dominion Government's contribution included also a breakwater, 18,600 ft. in length from the western entrance of the harbour to the Humber river.

### Welland Ship Canal

The subsequent completion of the Welland ship canal, and increased trade by water has resulted in these facilities being fully utilized. In 1934 to 1936, under the Public Works Construction Act the Dominion constructed the Marginal Way dock, and completed section 10 of the original development (Fig. 5).

Burlington Bay, on which is situated the important manufacturing city of Hamilton, is separated from Lake Ontario by Burlington Beach, through which the Government has maintained a channel for over 100 years. This channel was deepened and widened to coincide with the Welland ship canal opening, provision being made for an ultimate depth of 27 ft. Highway traffic across the canal, probably of higher intensity than on any other route in Canada, uses the double leaf bascule bridge which replaced the earlier bridges, they in turn succeeding the original ferry.

As the completion of the Welland ship canal would allow vessels of Upper Lake capacities access to Lake Ontario and transfer their eastern transfer terminus from Port Colborne, on Lake Erie to a port on Lake Ontario level, the Department selected Prescott as the most logical place of trans-shipment and erected there a grain elevator of 5,500,000 bushels capacity, equipped for transfer of grain from Upper Lake to canal boat, or to rail. The channel from Lake Ontario to Prescott was improved to St. Lawrence Deep Waterway dimensions as a joint undertaking with the United States, each country carrying out the improvement in its own territorial waters.

The instances cited above are from the larger and better known harbours. With the development of the larger national harbours a desire developed at each centre for a means whereby those locally interested might share in the plans for its harbour, and Harbour Commissions were provided for by legislation, the financing for capital expenditures being by loans from the Dominion. In this way the activities of the Department of Public Works largely ceased at these places, except for improvement or maintenance of main entrances thereto, by breakwaters, channel piers, or dredging. By recent legislation, after the report of his study of conditions made by Sir Alexander Gibb, control of the harbours formerly financed by Dominion loans has been vested in the National Harbours Board under the Minister of Transport.

### Harbour and River Development

The requirements of the people of Canada in carrying on their business where water transportation is a factor have, however, been continuously met under the Department of Public Works, the growth in this direction being indicated in the following table, and in the graph of yearly expenditures under the Department (Fig. 6).

| | |
|---|---|
| 1882 | 199 works |
| 1892 | 387 works |
| 1902 | 571 works |
| 1912 | 1,244 works |
| 1925 | 2,221 works active |
| | 28 works abandoned |
| 1932 | 2,976 works active |
| | 281 works abandoned |
| 1934 | 3,164 works active |
| | 327 works abandoned |

Since the general conception of the prairie provinces is that of a vast field of grain it is worth noting that in 1934 there were sixty-five active works under the Harbours and Rivers division, and that eleven works of this category previously carried out had been abandoned.

### FISHERIES

The extent of the fishery resources of Canada may be judged from the facts that from Grand Manan to Labrador is a coast line of over 5,000 miles, that the Gulf of St. Lawrence is over 80,000 square miles, and the Bay of Fundy over 8,000 square miles in area, and with other waters comprise an area of fully 200,000 square miles of fishing grounds. The area of the Great Lakes in Canadian territory is some 34,000 square miles in extent; in the prairie provinces, Lakes Winnipeg, Winnipegosis, Manitoba, and Athabasca, have a combined area of 16,359 square miles, and Great Bear and Great Slave lakes, in the North West Territories, add 22,830 square miles to the list. The coast line of British Columbia is 7,180 miles in length.

In 1887 the fish catch was valued at $18,386,103, of which the prairie provinces contributed $129,084, and British Columbia $1,974,887; in 1935 the value was $34,427,864, British Columbia's fisheries accounting for $15,169,529, and the prairie provinces and Yukon for $1,756,860. In the latter year the invested capital was $43,617,888, and 82,918 persons were employed.

The value of the products of this industry exported in 1935 was $24,859,486, shipments going to 87 countries. This is exceeded only by the export fisheries trades of the United Kingdom and Norway.

From the nature of their calling fishermen are generally best served by harbours of moderate dimensions situated within reasonable distance of the fishing grounds and their homes.

### Harbour Development Problems

The engineering problems in the development of such harbours arise largely from the varying local conditions of the nature of the coast, exposure to storms, tidal or other current direction and strength, the variation in level, and winter weather conditions, especially the formation of ice, and mass ice movement. The local availability of construction materials, the prevalence, or otherwise, of teredo or limnoria in sea water, and the probable length of life to be required from the works must also be considered.

It is from the experience gained from observation during the development of the smaller harbours that there has been possible the progress made to the present day in other deep sea harbours and harbour works.

### SECONDARY HARBOURS

While we think of Halifax and Saint John as Canada's eastern winter ports, of Montreal and Quebec as eastern summer ports, and of Vancouver, Victoria and Prince Rupert as the western outlets, these are really the seaboard harbours through which our foreign commerce flows. In the collection of products for export, and in the distribution of imports from abroad, the lesser or secondary harbours play possibly an even greater part in the much larger internal trade of the country.

The development and maintenance of these secondary harbours on the sea coasts and on the shores of the Great Lakes, has been one of the main responsibilities of the Department. Ports such as Nanaimo, Powell river, Ocean Falls or Port Alberni on the Pacific coast; Liverpool, Hantsport, Bathurst or Rimouski on the Atlantic side, are only a few examples. On the Great Lakes, Cobourg and Oshawa on Lake Ontario; Port Stanley and Rondeau on Lake Erie; Goderich and Midland on Lake Huron, may also be mentioned.

During the fiscal year 1935-36 harbour and river works under the Department were completed at over seventy of these secondary points in all parts of Canada.

### Physical Characteristics

The factors influencing the location and development of harbours in Canada are many and diversified. On the Bay of Fundy the tides have a range of from 15 ft. at Yarmouth, through 27¼ ft. at Saint John, to 45½ ft. at Hopewell Cape, and 51½ ft. at Burntcoat Head. Vessels berth at high tide and lie aground during the lower portion of the tidal range, so that gridirons have been developed, in which vessels may ground much as if they were in dry-dock. These can be seen at Port Williams, an apple shipment port for the Cornwallis valley, and at Windsor, a lumber and gypsum shipping port.


**Fig. 6—Expenditures under Public Works Department 1866-1936.**

The Atlantic coast of Nova Scotia is quite different, being deeply indented and generally rocky. Harbours on this coast are generously provided by nature. The facilities provided for fishing and lumbering industries take the form of channel improvements by dredging, and the construction of piers and breakwaters. Yarmouth harbour has been greatly improved by dredging, and is the port through which much of the trade between Nova Scotia and Boston and New York is carried. The Port of Lunenburg, the centre of the salt bank fishing industry, has been similarly improved.

Conditions on the north coast of New Brunswick are largely similar to those on Prince Edward island and the Magdalen islands. The tidal range has lessened, to between 3 and 5 ft., and the shipping season is curtailed by ice in winter, whereas the outer part of the Bay of Fundy and the eastern coast of Nova Scotia are practically ice free. Characteristic of this coast, as regards harbour work, is that wide mouthed and shallow bays have been formed, generally negotiable by only the smaller classes of fishing boats. It is under these conditions that the ingenuity of the engineer finds an opportunity of trying to form a stable harbour in the midst of naturally unstable local conditions.

On the Quebec coast of the Baie des Chaleurs, westward of Gaspé harbour, the shore is generally abrupt, and of limestone or conglomerate, so that it is mainly where the rivers debouch that harbours have become established. At some points currents have moved eroded material along shore, resulting in the formation of the interesting lagoons or "barachois" found at Carleton, at Paspebiac, and at New Carlisle. That at Paspebiac has a frontage at the shore line of 6,800 ft. and projects 4,800 ft. seawards (Fig. 7). Similar conditions account for the formation of Point Pelee, on the north shore of Lake Erie.

Of another type is the bar, or island, which has been formed by the action of currents on eroded material from the Scarboro bluffs, and which encloses Toronto harbour (Fig. 5).

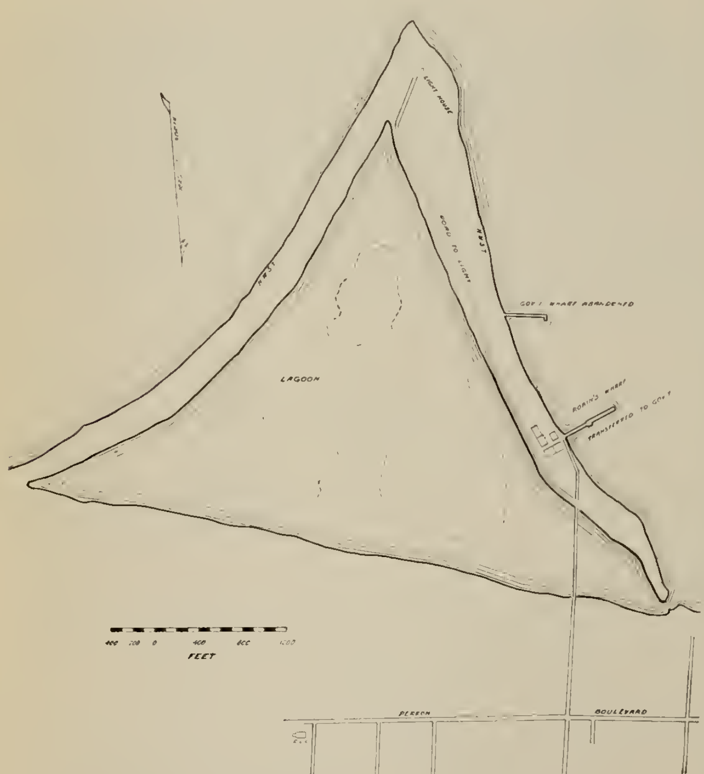



Fig. 7—Barachois at Paspebiac, Que.

If harbour accommodation is not available within the sheltered area at the mouth of a river, or that provided by some natural feature, breakwaters must be used. The rubble mound type of breakwater has been used at Port Arthur, Saint John, Victoria and elsewhere.

Stone ballasted timber-crib construction may be employed where the breakwater is to be used also as a landing wharf. Reinforced concrete cribs have been used successfully, the earliest of the type in Canada being that built in 1912, at Goderich on Lake Huron. Stable foundation conditions are necessary where that type is used, an advantage of the timber-crib or of the rubble mound types types being the flexibility which allows them to conform, with minimum subsequent repair expense, to an unstable foundation.

The most noticeable difference between the types of most harbour works on the Atlantic coast, the Great Lakes and interior lakes or waters, and those used on the Pacific arises from the absence of ice-forming winter conditions and also from the generally greater degree of shelter available on the Pacific coast. There structures are generally of timber pile construction, due to the economic accessibility of that material, although protection against teredo is necessary.

### Dredging and Dredging Plant

The steady increase in size of ships and the depth of water they require has required a great deal of dredging work by the Department. In 1892 the dredging fleet used in the improvement of Montreal harbour and the ship channel consisted of:—

Four elevator dredges,
Five tugs,
Three stone lifters,
Twelve dump scows of 80 cu. yd. capacity,
Two dump scows of 150 cu. yd. capacity,
One store ship,
One sounding scow,
Two flat scows,
Two coal barges.

At the commencement of the Great War the Department had floating plant of a value of approximately five million dollars, distributed on the Atlantic and Pacific coasts, the Great Lakes, and the interior lakes of the prairie provinces and British Columbia.

The equipment, supplemented by the use of privately owned plant used on works awarded by tender, brought about an extensive betterment in channels and harbours. All modern types of dredges, rock breakers, tugs, scows, etc. were included. The necessity for retrenchment in expenditures, together with the advanced state of the improvements at that time warranted the disposal of the major part of the fleet. Since the war the Department has maintained the more generally useful and adaptable units, and has carried out a large part of the dredging needed, by contract, after public competition.

In this way the Department, by keeping accurate record of cost of operation of its own plant, is in a position to prevent inflation of prices by private owners of plant; if necessity arises unexpectedly for dredging to be done the departmental plant can be diverted thereto without delay; if need arises for curtailment of expenditure the plant of the Department can be shut down, whereas on contract work the Department is bound to fulfil the terms of the contract. A further circumstance is that on contracts involving large quantities and extending over considerable time the contract rate cannot be altered to take advantage of any reduction in operating costs, whereas such reductions would be reflected in costs of departmental plant operations; on the other hand increases in such costs, if of any moment, may result in claims for compensation from contractors.

### PIONEER DEVELOPMENT

The development of Canada would present a vastly different picture without the adventurous, pioneering spirit which has characterized the peoples who have sought its shores. As they penetrated farther and farther into the interior their first means of transportation was by the waterways. As development continued, roads and railroads were built to provide safer and swifter transport, and the waterways became less used. But the economy of water transport remains a factor available for use as development proceeds, and to supplement other man-made means of communication and transport.

The present mining development in northern Quebec, tributary to the Harricana river, may be taken as an illustration. Rising north of the height of land and flowing north to James Bay the resources of timber or of the agricultural areas on its watershed were not economically exploitable. The construction of the National Transcontinental Railway, crossing the rivers of the northerly slope of that area, provided a means of transport to market of the lumber, and of the produce of farms. The supplies of machinery for saw mills, and for lumber camps had to be handled by the river. In 1919 a small dredge was assembled at Amos, where the river and railroad meet, for use in improving the main and branch channels of the river, which until then was not usable for craft of over 3½ ft. draft, and only for a distance of about 4 miles above Amos. About the same time the development of the gold resources of the region began, the original development work on the Siscoe mine commencing in 1920. There are now eleven plants in operation handling from 100 to 600 tons of ore per day. Thus the waterway improvements have had to be continued, the channels maintained and improvements carried farther afield as more properties were opened up.

As development demanded, the provincial government has since constructed highways; railways were also added, the Nipissing Central being built in 1928, and the Canadian National having now under construction a branch line from Senneterre through Val d'Or to Rouyn. The growth of the district and of the water-borne traffic may be indicated as follows:—

1920—Approximately 12,000,000 ft.b.m. spruce and jack pine in round logs towed down the river by steamers, and about 200 tons of mining and lumbermen's supplies.

1936—Approximately 350,000 ft.b.m. of timber and 180,000 tons of machinery and supplies (including gasoline) moved by water.

The future of the region seems assured for many years to come, and the wisdom of the expenditure to aid the pioneers and their successors is amply demonstrated.

In the Maritime provinces, the accessibility of the sea coast has rendered services of this nature largely unnecessary, but the St. John river and its large tributaries, and the Miramichi river, both in New Brunswick, are used as waterways.

The Yamaska, the St. Francis, the Lievre and the larger tributaries of Lake St. John in Quebec, the Trent, the Grand and the Thames rivers in old Ontario, and in later years the Red, the Hole and the Echimamish rivers in Manitoba, the Saskatchewan, the Montreal, the Cumberland, the Beaver and the Meadow rivers in Saskatchewan, the Lesser Slave and the Peace in Alberta, and the Columbia, the Fraser, the Stikine, the Finlay, in British Columbia, together with the Yukon river, among many, form other examples of the varied uses of the waterways in facilitating the pioneering efforts of Canadians, and of the diversity of public works required, such as dams, training works, lining cables, removal of boulders and snags, and dredging.

### Bridges

Mention has been made in the earlier part of this paper of the activities of the provinces of Canada in the construction of roads, and as a result of these works and the canal construction, the present policy of the Dominion in respect to the construction of highway bridges has developed.

The Ottawa city bridges, maintained by the Department, include the Laurier bridge over the Rideau canal and C.N.R. tracks (rebuilt 1901), and the Connaught Plaza, built in 1912 to replace the old Dufferin and Sappers bridges crossing the canal at Sparks and Wellington streets.

Incidentally, Colonel By, R.E., who built the Rideau canal, also bridged the turbulent Chaudiere channel between Upper and Lower Canada in 1837, with an arch bridge, successively replaced by a suspension bridge in 1843, a pin-connected truss bridge in 1899, and a riveted truss bridge in 1919; a good example of the changes required to meet increasing traffic demands across the Ottawa during the past century.

Fig. 8—Bow River Bridge, Banff, Alta.

When reconstruction of the Union bridge below the Chaudiere falls was necessary in 1919, the cost was borne share and share alike by the Dominion and the two provinces of Quebec and Ontario, subsequent upkeep being assumed by the Dominion. The bridges at Bryson (1886); Portage du Fort (1901 and 1904); Chapeau (1876 and 1912); DesJoachims (1886); and North Timiskaming (1919), on the Ottawa river were constructed at Dominion expense, as a liability connected with the Ottawa river slides and booms and storage works, and as a contribution towards the development of the district.

The original Intercolonial Railway bridge over the Restigouche river, the boundary between Quebec and New Brunswick, having become too light for heavy rail traffic, the Dominion assumed the bridge, and has maintained it for highway traffic.

A bridge over the Assiniboine river near the boundary between Manitoba and Saskatchewan, near Shellmouth, Man., was built and is maintained by the Department. Several bridges were also built in the North West Territories, at Battleford; at Calgary (1897); MacLeod (1897); Edmonton (1899), and the Banff, Alta. bridge was rebuilt (1920) (Fig. 8).

The bridge over the Ottawa river between Hawkesbury, Ont. and Grenville, Que. was built in 1930 under the policy which has been adopted of constructing bridges, where warranted, over interprovincial waterways, when the adjoining provinces will absorb equal shares of the cost with the Dominion; subsequent maintenance, not including replacement, being borne chiefly by the Dominion. This does not apply to bridges wholly within a province, the cost in such cases being considered as the affair of the province.

Bridges over streams forming part of the International Boundary are in a different category, and the policy is to construct such bridges as are considered warranted, for highway traffic, in conjunction with the appropriate authority in the United States, each bearing one half of the first cost and subsequent maintenance. The bridges at Edmundston, Clairs, and St. Leonards, over the St. John river, and that at Vanceboro over the St. Croix river, boundary streams between New Brunswick and Maine, are in this class.

The LaSalle causeway and bridges, over the outlet of the Cataraqui river at Kingston, Ontario, arise out of the main provincial highway constructed by the province of Canada prior to Confederation, and in this case over a reach of the Rideau canal, a continuing liability of the Dominion.

**Fig. 9—Lift Bridge, Selkirk, Man.**

The construction programme of the Dominion undertaken for the relief of unemployment, during the recent depression, provided funds for the construction of highway bridges over the Red river at Selkirk, Man. (Fig. 9); over the South Saskatchewan river at Outlook, and over the North Saskatchewan at Borden,[9] in Saskatchewan. These, being within their boundaries, will be turned over to the province on completion.

### Aviation

The development of aviation in Canada has been under the supervision of the Department of National Defence in both its military and civil aspects. That Department, however, enlisted the aid of the engineering services of the Public Works Department in the development of the landing field, at St. Hubert, P.Q., and in the provision of mooring facilities there for H.M. dirigible R-100.[10]

### The Dry Docks Subsidies Act

Running through the reports from year to year of the Public Works Department are descriptions of governmental activities to safeguard ships against possible accident.

Since it is inevitable that damage to ships will occur, repair facilities must be provided. For the smaller classes of vessels, up to about 3,000 tons, marine railways are built, but above about that limit recourse must be had to dry docks.

To supplement the lighthouses, buoys, and other aids to navigation, and channel improvements, and as a means of keeping down insurance rates, the government built the Lorne dry dock, at Levis, Que., in 1888, and the dry dock at Esquimalt, B.C., in 1887. These were adequate to receive the largest ships of that time, up to about 25 ft. in draft and 500 ft. in length.

On the Atlantic coast of Canada there was no corresponding facility, and to meet the situation the Halifax Graving Dock Company Limited was subsidized by the Dominion Parliament. The British Government assisted by subsidy in the construction in order to have a repair base for the North Atlantic Squadron, and financial assistance was given by the city of Halifax. The Halifax dock was built in 1886-1889.

As the first decade of this century brought increasing trade through the St. Lawrence route with correspondingly larger ships, and in view of possible expansion of the ship building industry in Canada the Government, to aid both the shipping and the shipbuilding industries enacted the Dry Docks Subsidies Act. Under its terms private companies could secure, on a favourable report by the Minister of Public Works as to the need of the facility, a guarantee of reimbursement of the cost of construction of graving or of floating dry docks with ship repair facilities, the Act setting out the minimum dimensions and capacities the subsidized structures are required to have.

Under the provisions of the Act dry docks were subsidized, as follows:

| Year completed | Place | Type | Dimensions |
|---|---|---|---|
| 1904 | Collingwood, Ont. | Graving | 526.15 ft. by 59.8 ft. by 14.8 ft. |
| 1910 | Collingwood, Ont. | Graving | 413.2 ft. by 95 ft. by 19.2 ft. |
| 1910 | Port Arthur, Ont. | Graving | 723.4 ft. by 77.6 ft. by 16.2 ft. |
| 1912 | Montreal, P.Q. | Floating Class II | 601 ft. by 100 ft. by 32.6 ft. |
| 1915 | Prince Rupert, B.C. | Floating Class II | 600 ft. by 103 ft. by 32 ft. |
| 1923 | Saint John, N.B.[11] | Graving Class I | 1,164.6 ft. by 131 ft. by 40.3 ft. |
| 1925 | Vancouver, B.C. | Floating Class II | 556.6 ft. by 104 ft. by 28 ft. |

**Fig. 10—"Duke of Connaught" Floating Drydock, Montreal.**

To meet the need of adequate drydocking facilities for the larger ships on the St. Lawrence, the Government constructed the Champlain dry dock, at Levis, Que., work

[9]The design and construction of this bridge are described in another paper by Messrs. C. J. Mackenzie, M.E.I.C., Dean of Engineering, University of Saskatchewan, and B. A. Evans, Senior Assistant Engineer for the Department of Public Works of Canada.

[10]The St. Hubert Airship mooring tower has been described by R. deB. Corriveau, M.E.I.C., assistant chief engineer. See The Engineering Journal for April, 1930, pp. 277-281.

[11]The Saint John, N.B. Dry Dock, by E. G. Cameron, M.E.I.C., The Engineering Journal, October, 1923.

being commenced in 1911 and the dock taken over from the contractors in 1921.[12] The need of larger facilities than those already existing on the Pacific coast was met by the construction of the New Esquimalt dry dock, at Esquimalt, B.C., in 1920-1926, by the Department.[13] It is 1,150 ft. long, 125 ft. clear width at entrance, and carries 40 ft. over the entrance sill at high water. (See Fig. 12.)

**Fig. 11—Drydock, Saint John, N.B.
(H.M.S. Norfolk in dock.)**

THE NAVIGABLE WATERS PROTECTION ACT

From earliest times man has made use of the facility provided by waterways in his business affairs, and the reservation of this right of common user to the public descends to us in the Common Law of England.

Parliament did not enact legislation to protect the public against damage or obstruction to the navigable waterways until 1886, when it passed the Navigable Waters Protection Act. This arose from the need of checking the harmful practice of dumping the refuse from saw mills into streams and lakes. As industry developed the need of wharves or piers, of bridges, or telegraph or telephone or power lines or other works which might affect the use of the waterway by commerce, the scope of the Act was extended in 1927. As now enacted, any work is unlawful if constructed in, over, under or through a navigable body of water in Canada if the approval of the Governor-General-in-Council is not obtained prior to construction, and if a work, not so approved, is considered by the Governor-General-in-Council to be an obstruction to navigation he may order its removal at the expense of the owner. The Act applies to works of any private individual or corporation, or municipality or provincial government. It does not apply to bridges over the St. Lawrence river, for which structures special Dominion legislation is individually required.

Part I of the Act, which relates to works in navigable waters, is administered by the Department of Public Works, while Part II, relating to the depositing of materials in navigable waters is administered by the Department of Transport.

PRECISE LEVELLING

In the course of the development, in its several stages, of the deep water channel of the St. Lawrence river to Montreal, from the original natural depth of 12 ft. to the present depth of 35 ft. at low water, it became increasingly important that accurate knowledge be available of the true level of the sloping surface of the river in relation to mean sea level.

To secure this basic information precise or geodetic levelling was inaugurated in Canada in 1883, the first work being done on that section of the Richelieu between St. Johns and Rouse's Point on Lake Champlain, N.Y.; the datum assumed was at a height of 100 ft. above the zero of the U.S. Engineer Corps at Fort Montgomery, N.Y.

The first few seasons' work embraced the whole Richelieu river from Lake Champlain to the St. Lawrence at Sorel.

Work on a line between Montreal and Quebec along the south shore of the river was started in 1885 and completed in 1888. It was decided by the Department that work be pushed along from Quebec towards the Atlantic coast, and westwardly to the Great Lakes. Below Quebec the work would be of great service almost immediately, in connection with the proposed determination of the low water plane to which soundings could be reduced in the Beaujeu channel, previous to engaging in expensive sounding operations, and also the connect determination of mean sea level at some point in the gulf.

Seasons were spent in establishing flood levels between Lachine and Quebec. Tide stations were maintained between Levis and Champlain and one far down in the gulf, at Rivière aux Renards (Fox river).

Levelling continued along the beach of the south shore of the gulf to some 25 miles beyond Father Point, where the right-of-way of the Intercolonial Railway was used for the first time. By 1903, after twenty years, the total length of line levelled, including cross sections, was 637 statute miles, and the number of metallic and other permanent bench marks established, 261.

**Fig. 12—New Drydock at Esquimalt, B.C.**

In 1904 work began in connection with the extensive surveys undertaken by the Department on the projected ship canal from the Georgian Bay in Lake Huron through the valleys of the French and Ottawa rivers down to Montreal. This was completed in 1906, and the mileage was 889.

In 1907 the levelling reached Halifax, where connection was made with the bench mark used by the Tidal Division of the Hydrographic Service in establishing mean

[12]The Champlain Dry Dock, Engineering News, December 18, 1913.
The Champlain Dry Dock for Quebec Harbour, by U. Valiquet, M.E.I.C., Trans. Can. Soc. C.E., 1918.
[13]The New Esquimalt Dry Dock, by J. P. Forde, M.E.I.C., The Engineering Journal, December, 1925.

sea level. Mean sea level at Halifax is now the datum to which all records are reduced. The main base line between Halifax and Father Point, across almost three provinces, and nearly 500 miles long, turned out to be of great accuracy.

With the completion of the main line, work was systematically extended. The lower provinces offered a great field for checking accuracy at the various harbours and ports in establishing low water datum for charts and design of harbour works, and dredging. In Nova Scotia and New Brunswick about 1,000 miles of levelling was done.

In Quebec a large loop line some 450 miles long was run, starting at Matapedia and following the shore of Baie de Chaleur, across Gaspé harbour, thence over the route (now the new highway) to Fox river and along the north west shore of the gulf to Father Point. Including cross sections and spur lines some 2,100 miles were covered.

In Ontario the main line followed the upper St. Lawrence to Lake Ontario, then from Toronto to the Welland canal and across Niagara to Lake Erie, thence along the shore line to Windsor, finally to Sarnia and Point Edward, covering over 1,900 miles including the Georgian Bay work.

In Manitoba the work requested started at Stephen, Minn., and reached the boundary at Emerson, continuing to Lake Winnipeg.

Between 1883 and 1930 the total distance amounted to 5,500 miles.

Having accomplished the object of relating to mean sea level the elevations of permanent bench marks from which to establish the true height of the surface of the majority of Canada's navigable waterways and harbours, these activities of the Department were discontinued, and the records were transferred to and incorporated with those of the Geodetic Survey of Canada.

### Testing Laboratory

The present testing laboratory of the department was inaugurated in 1892, as a cement testing laboratory, and continued until 1911 testing Portland cement exclusively, when the activities were extended to testing gravels, crushed stone, reinforcing steel, and brick. Towards the close of the Great War, and coincident with the reconstruction of the Parliament building at Ottawa, the field of usefulness was greatly extended, so that it now covers all classes of materials used in building construction and of goods purchased for government use, as well as processes.

The experience gained in the testing and examination of these goods and materials has been incorporated in specifications under which these are purchased for departmental use. A further development of great promise has been to correlate field and laboratory tests and studies of foundation materials and conditions.

With the development which ushered in the present century, the engineering activities and staff of the Department of Public Works expanded to the extent that some 36 districts had been established, with the staffs in proportion. The realignment of effort consequent on the Great War necessarily imposed on the department, as on other governmental activities, a curtailment of effort, and this resulted in a reorganization under which the districts were consolidated to sixteen in number, and with a reduction in staffs to correspond.

In view of the manifold and diversified activities of the Public Works Department throughout the Dominion, including not only the nine provinces but the North West Territories and the Yukon, a basic scheme of decentralized administration has been found the most suitable and effective, as it permits a close contact being kept not only with the works but with the trend of business, and permits of that degree of flexibility necessary to meet changing conditions.

### Chief Engineers of the Department

Samuel Keefer was the first Engineer of Public Works of Canada. Born at Thorold, Ontario, January 22nd, 1811, he was Secretary and Assistant Engineer of Public Works of Canada, 1833-1841, becoming Chief Engineer on August 17th, 1841, which office he held until 1852. He was the second president of the Canadian Society of Civil Engineers.

John Page, senior, succeeded as Engineer of Public Works on November 5th, 1853, and continued in the capacity of Engineer of Public Works after Confederation. He stayed with the Canals, becoming the first Engineer of Canals when the separate Department of Railways and Canals was formed in 1879.

Henry F. Perley, who had served his apprenticeship on the engineering staff of the Government of New Brunswick which he joined in February, 1848, with that of the Nova Scotia Government from 1863 to 1865, then as Superintending Engineer of New Brunswick Railways from 1870 to 1872, as Superintending Engineer of Public Works for the Maritime Provinces from May, 1872, succeeded John Page in 1880, and held office until 1890. He was the first "Chief Engineer" of Public Works, that title being created and conferred on him by Order-in-Council of November 25th, 1880. In 1887-1889 he was vice-president of the Canadian Society of Civil Engineers.

Louis Coste, M.Can.Soc.C.E., who had been an engineer on Public Works from 1884, succeeded Henry F. Perley, and was in turn succeeded by Eugene D. Lafleur, in 1899.

Mr. Lafleur, who died in harness in 1922, after continuous service since September 27th, 1881, had seen major developments under the Department initiated and carried out, including the construction of the Champlain dry dock at Levis, the deep water wharf on the River St. Charles at Quebec, the ocean terminals and the dry dock at St. John, N.B., the Georgian Bay Canal Survey, the development of Port Arthur and Fort William, and of Vancouver and Victoria, in British Columbia.

His successor, Arthur St. Laurent, past president of the Engineering Institute of Canada, had joined the public service with the Department in 1885. A man of sound judgment and wise counsel, he had gained the respect, esteem and affection of all, and his untimely death in 1923 was a great loss to the public service.

**Fig. 13—New Customs Building, Montreal.**

The author, then occupying the position of Assistant Chief Engineer, succeeded Mr. St. Laurent.

### Government Telegraphs

The Government telegraph and cable lines, which have been under the control of the Public Works Department since 1879, have played an important part in Canada's development since that time.

Following the construction of a telegraph line which was to connect Halifax with the trans-Atlantic cable terminal at Canso, telegraph and cable lines soon began to function as aids to fishing and navigation along the coast of the Gulf of St. Lawrence and the Bay of Fundy. In addition, submarine cables were laid to such important fishing centres as the Magdalen islands, Anticosti, and Grand Manan islands.

Well in advance of the construction of the Canadian Pacific Railway, the Government telegraph lines passed beyond Winnipeg and extended out over the Saskatchewan and Alberta prairies and, upon the incorporation of British Columbia into the Dominion, the Public Works Department took over the privately owned land and cable lines then in operation in that new province.

From this small beginning, there has developed in the past fifty years the present Government Telegraph Service, with some ten thousand miles of land line, serving many of the important agricultural, timber, fishing and mining areas in eight provinces and the Yukon Territory.

A factor which contributed to the early development of the telegraph service along the Gaspé coast was the necessity of establishing a system of news broadcasting for the fishermen there. Daily bulletins were sent over the wire by each office between Matane, on the St. Lawrence side of the Peninsula, and New Carlisle, on the Bay of Chaleur, reporting:

1. The result of the local fishing on the previous day.
2. The bait supply of the preceding night.
3. The prospect for cod fishing; the state of the weather and the wind of the day up to the moment the bulletin was sent over the wire.
4. The Meteorological Bureau's probabilities and storm warnings.

Each office made manifold copies of these reports, which were prominently displayed and passed out to the fishermen.

Another factor which stimulated the policy of telegraph line construction along the St. Lawrence river and gulf coast was the growth of steamer traffic on the Strait of Belle Isle route. This resulted in the building of a line slightly over a thousand miles in length between Quebec and Belle Isle.

The Department undertook the construction of this line along the north shore of the St. Lawrence river and gulf from Murray Bay to Chateau bay, Labrador.

The work was arduous. It was carried on each season during the period of navigation, for in the absence of roads of any kind, the employment of schooners was necessary for the transportation of poles, wire, provisions, and workmen. It was not until 1901 that the last pole was planted at Chateau bay, and a submarine cable laid out to the important lighthouse located on Belle Isle.

In British Columbia up to 1885, quite an extensive telegraph system had been put into operation. After the original purchase, from the Western Union, of the lines and cables in British Columbia, which represented 430 miles of land lines and 16 nautical miles of cable, the service was extended by new construction and by adding to the lines already in operation. In 1885, the lines in this new western province had a length of 676 miles.

The main line of the C.P.R. having been completed, the activity in the west was largely confined to the centres touching or in close proximity to the railway. Possibly for this reason, telegraph construction up to and between 1885-1898 was limited to the construction of some 200 miles of line on the south coast of Vancouver island and on the mainland.

In the east, some attention was given to cable laying, with the result that the following islands were furnished with a means of communication by submarine cable:

**Fig. 14—New Public Building, Winnipeg.**

Ontario—The important agricultural area on Pelee island was connected by cable and land line to Leamington.

Quebec and Maritime Provinces—Brier island and Digby Neck were given cable service.

A cable was laid between the coast of Cape Breton and St. Paul's island, which is located in the main shipping channel 19 miles from the northern part of Cape Breton island.

A cable was laid between Mingan, on the northern shore of the St. Lawrence, to Anticosti island to permit direct communication between these two areas.

Communication was established between Shippigan island and Miscou island, N.B., by the construction of 23 miles of land line.

Ile aux Coudres, in the St. Lawrence channel, was connected with Baie St. Paul.

In 1898, the announcement that much gold had been discovered in the Yukon started thousands of miners up the trails from Skagway and Dyea, Alaska, and thence by boat and scow downstream from Lake Bennett to Dawson. This called for quick action in providing communication with these new gold fields.

Upon the arrival of telegraph material at Lake Bennett, construction was immediately begun, and within a year 565 miles of line brought Dawson into touch with the outside. Between Lake Bennett and Skagway the wires of the White Pass Railway were used. From Skagway south, communication was by steamer. The Government line under the Public Works Department was next extended southward to Atlin, and two years later the line had reached Quesnel, 885 miles southward, by way of Telegraph creek and Hazelton, to tie-in with the line which was then in operation between Quesnel and Ashcroft, B.C. This line was, in 1902, extended 90 miles north of Dawson to the Alaska boundary to connect with the U.S. Army system operating in Alaska.

Between the years 1900 and 1910, increased activity was displayed in providing telegraph lines in various parts of Canada, particularly in British Columbia.

During the early years of the War, notwithstanding the activities overseas, the Government Telegraph Service extended its communication lines to serve many rapidly developing outlying points, largely in British Columbia and Northern Alberta.

Fig. 15—New Public Building, Moncton.

The extent to which the Government Telegraph Service had developed up to and including the year 1916 is reflected in the fact that in the above-mentioned year the mileage of the government lines held second place amongst the telegraph services in Canada. The figures are as follows:

| | Land line | Submarine cables |
|---|---|---|
| Great North Western Telegraph Company..... | 10,064 | 13 |
| Canadian Pacific Telegraph Company.......... | 14,617 | 95 |
| Government Telegraph Service................ | 11,516 | 336 |
| Grand Trunk Pacific Telegraphs.............. | 5,277 | 1 |

In the years immediately following the War, the mileage of the Government Telegraph Service reached its highest figures.

During the period, however, from 1925 to 1931, owing to the construction of additional railways in the West and the adoption of a policy of expansion on the part of the British Columbia Telephone Company, certain lines, both telegraph and telephone, having served their purpose as pioneer undertakings, were abandoned or sold.

At the time of the construction of the trans-Canada telephone system in 1928-29, the British Columbia Telephone Company, wishing to extend their lines eastward to the Alberta border and develop the telephone field on the south-easterly portion of British Columbia, negotiated with the department for the sale of its lines in that teritory. This purchase was on a rather large scale and brought about the transfer of 1,666 miles of pole line and 3,000 miles of wire to the Telephone Company

Pursuing the same policy of expansion several years later, the British Columbia Telephone Company purchased telephone lines on Vancouver island from the department to the extent of 223 miles of poles and 455 miles of wire.

During this period other lines in Saskatchewan and Alberta, having served the purpose for which they were constructed, were also abandoned to avoid duplication of telegraph services, the railroads having entered the fields formerly served exclusively by the department.

While the department was disposing of non-essential lines in certain sections, new fields requiring telegraph and telephone facilities were not neglected. The policy of the department was to furnish communication and service to localities urgently requiring same and which could not be be served by other agencies. Thus in 1929 an important telegraph line was constructed between the town of Peace River and the thriving frontier settlement of Fort Vermilion, 253 miles to the north.

In British Columbia there is no provincial telephone system as is the case in Alberta, Saskatchewan and Manitoba. For this reason the Government Telegraph Service is called upon to provide local telephone service for quite a few of the towns in that province which have not grown to such a size as to attract the attention of commercial telephone organizations. Some of these communities have grown up around the original government telephone office and are now given local telephone service through switchboards established therein. Some of the larger places enjoying such service are: Ashcroft, Clinton, Lillooet, Lytton, Williams Lake, Burns Lake, Smithers, Vanderhoof, Hazelton and Alert Bay. More than 1,100 subscribers take this service.

The recent recurring drought years in Southern Alberta and Saskatchewan brought about quite an extensive migration of settlers to the well-watered land in the Peace River Block. In this area the department was called upon to construct some hundreds of miles of rural telephone lines. The growing towns of Pouce Coupé and Dawson Creek, the latter at the terminus of the Northern Alberta Railway, have been given local and long distance telephone service through the telephone exchange located in each of these centres. This is in addition to a fast telegraph service to all important points between Hudson Hope, in the extreme westerly part of the Block, and Edmonton. This line is operated as one circuit and has a length of 720 miles.

In the east, the major construction work undertaken in recent years was the rebuilding of the western portion of the forty-year old line which follows the north shore of the St. Lawrence. This was made necessary to provide for the requirements of the pulp and paper industry along the coast. Within the last fifteen years, some of the larger paper interests have established pulp operations at many places along the coast as far east as Seven islands. A new cedar line, carrying two wires, has been completed as far as that point, a distance of 350 miles.

Fig. 16—Administration Building, Central Experimental Farm, Ottawa.

The laying, in 1930, of the fourth submarine cable across Northumberland strait to Prince Edward island was an important addition to the communication service to that island province. This new installation is the latest type of telephone cable and in addition to long distance telephone lines, carries the Island's radio broadcasting service.

Except in a few instances in the last ten years, when the department has built lines into outlying areas, it has been occupied more or less with the increasing of facilities in territories already served in a general way. The service as a whole has been and is a very important factor in Canada's upbuilding.

CANADA'S GOVERNMENT BUILDINGS

One of the main responsibilities of the Department of Public Works is that of providing and maintaining Dominion government buildings in various parts of the country. The extent to which this problem has grown may be judged from a few figures in connection with the Post Office and National Revenue Departments, which are perhaps those most familiar to the public. In 1886 there were 7,295 post offices in Canada. Fifty years later this number had increased to 12,156. As regards the Department of National Revenue, the number of persons employed in 1887 was 1,393, and in 1936 the number had risen to 4,620.

Recent figures indicate that nearly 53,000 persons are employed by the Dominion Government in all parts of Canada.

The increase in the number of public buildings under the Department of Public Works is indicated in the number of buildings owned and in use from time to time. In 1892 there were 159 buildings; in 1902, 285; in 1912, 328; in 1925, 428; in 1930, 593, and in 1936, 612 buildings.

The majority of Government buildings are erected and maintained by the Department of Public Works under the Chief Architect's branch. The great variety of buildings designed and the wide range of services therein accommodated may be realized when one mentions not only such departmental buildings as the Confederation, Justice and Connaught buildings, the East and West Blocks, the National Museum, the National Gallery, the Public Archives, the Royal Mint, the Central Experimental Farm, and the Dominion Observatory, all in Ottawa; but also such large Dominion buildings as those of Halifax, N.S., Moncton, N.B., large postal terminals and customs buildings at Montreal, buildings for the Royal Military College at Kingston, Ont., the Museum building at Louisburg, N.S., and the smaller post offices as at Notre Dame de Grace, Que., and Westport, Ont., not to mention armouries, barracks and military hospitals, quarantine, immigration and detention hospitals, fuel testing and ore dressing laboratories, research laboratories for the Agricultural Department, and many other types of buildings throughout Canada. Several of these classes are illustrated in Figs. 13 to 17.

In addition to the foregoing work carried out by the Chief Architect's branch of the Department of Public Works, it has been and still is the policy of the Government from time to time, when there is a particularly heavy building programme which would overtax the capacity of the Chief Architect's branch, to employ outside architects in private practice to design and supervise erection of buildings under the supervision of the Chief Architect. There are many excellent instances of these throughout the land. At Ottawa one finds examples of these in such works as the Parliament Building (with its Peace Tower, Memorial Chamber, Hall of Fame, and the two great Legislative Chambers of the Commons and the Senate), the new Postal Terminal, the National Research Building, and the Administrative Block of the Central Experimental Farm, whilst further afield the Dominion Government buildings at Hamilton, London, Regina, Vancouver, Winnipeg and Windsor are excellent examples of work carried out by the various practising members of the architectural profession outside.

It is interesting to note the trend of architectural taste as evinced from period to period by the buildings erected. There is no doubt that the natural topography of Ottawa with its commanding view calls for a skyline of pointed roofs and towers for its great legislative and departmental buildings, the best way of obtaining which was obviously to adopt a Gothic design. Whether, however, the original adoption of this style was not rather due to the Gothic revival in England at about that date, is a moot question. Suffice it to say that it was chosen, and happily so. In

Fig. 17—Customs and Immigration Building, Douglas, B.C.

later buildings, a tendency towards a Scottish Baronial type with an admixture of Perpendicular Gothic features can be noticed, as instanced in the National Museum, the Royal Mint and the Connaught Building. Today, as the Dominion government departmental buildings are spreading out to the west of Parliament Hill, the Gothic style is still retained, but of the Northern French Chateau type—perhaps the most appropriate style possible for this part of Canada from all points of view—aesthetic, climatic, sentimental and topographical.

What happened in Ottawa in respect to architectural design during the last fifty years has been to a large extent reflected in the designs of buildings throughout the Dominion.

During this period of development advantage has been taken of the opportunities offering to foster the use of building materials of Canadian origin. Sandstone from Nova Scotia; granite from Quebec; limestone from Quebec, Ontario and Manitoba; marble from Quebec and Manitoba, are among the Canadian materials employed.

To members of The Engineering Institute of Canada it is unnecessary to say that the efficient co-operation of members of their various branches of the engineering profession with those of the architectural profession, particularly during the last half century, has had most successful results in the design of the public buildings erected under the Department of Public Works.

ACKNOWLEDGMENTS

The annual reports of the Department of Public Works, both under the Union Government and since Confederation have naturally been the main source of the material used in this paper. Acknowledgment is due to the Dominion Bureau of Statistics' most valuable publications on Canada, in particular the "Canada Year Book" for information used therefrom, to "The Canadian Grain Trade," by Duncan Alexander McGibbon, to which anyone seeking for the knowledge of that subject should refer, and to the "Historical Atlas," by Lawrence J. Burpee.

To C. D. Sutherland, Chief Architect, and F. G. Sims, General Superintendent of Government Telegraphs, the author would express thanks for their invaluable assistance in those parts of the paper dealing with the activities of branches of the Department over which they preside.

# Chemical Engineering

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This subject is a large one and the broad field of modern chemical engineering makes it difficult to set limits to the scope of the discussion.

It is therefore proposed to deal largely in generalities outlining major developments only. At the end of this article there will be found a list of the more important chemical engineering developments in chronological order. It is not to be assumed that the story as given is complete nor are dates vouched for. It is hoped however that inaccuracies and omissions will be called to the author's attention with a view to their correction or inclusion at a later date.

The question is frequently asked—What is chemical engineering?

The subject has received much attention and discussion. To draw the line between the industrial chemist and the chemical engineer is virtually impossible.

The chemist who develops a process in the laboratory and then transforms it into a commercial operation obviously becomes a chemical engineer. Of necessity the chemical engineer is concerned with plant operations but there are few successful chemical engineers who have not worked in chemical laboratories.

The American Institute of Chemical Engineers has defined chemical engineering as follows:—

> "Chemical engineering as distinguished from the aggregate number of subjects comprised in courses of that name, is not a composite of chemistry and mechanical and civil engineering, but itself a branch of engineering, the basis of which is those unit operations which in their proper sequence and co-ordination constitute a chemical process as conducted on the industrial scale."

Fifty years ago chemical engineering was undefined and unrecognized as a definite branch of the engineering profession. Many of the commoner industrial chemicals of today were not manufactured and in many instances the processes on which their production is now based had been neither discovered nor developed. Canadian chemical industry existed on a small scale only and the application of chemistry to industry was in its infancy.

Fifty years ago sulphuric acid was being manufactured at Capelton, Que., making use of pyrites mined in the vicinity.

The manufacture of wood alcohol by the destructive distillation of hard wood had also been started. Black powder and nitro-glycerine were being produced at Beloeil. Small petroleum refineries existed at a number of points supplying kerosene and lubricants, but the internal combustion engine and the motor car had yet to be developed and to create the modern demand for petroleum products. Other chemical industries of importance were the manufacture of coal gas, and fertilizers, and potash recovery from wood ash, the latter still a substantial industry.

Another important infant industry was the manufacture of sulphite pulp which had just been undertaken in a small way at Hawkesbury, Ontario. Allied chemical industries such as brewing, distilling, sugar refining, tanning and soap manufacture had also been established and supplied the local markets.

The limited scope of the chemical and allied industries is shown in Table I* into which data supplied by the Department of Statistics at Ottawa have been incorporated.

However chemistry was on the march. The great scientific discoveries of the latter part of the 19th century had aroused public interest, and by 1885 chemistry courses had been established at our high schools and universities. There were thus becoming available trained chemists who were in a position to recognize the value of our natural resources, more particularly the mineral resources. Moreover a new industrial tool had just become available with the generation of electric energy on a large scale.

It was thus a logical development that in the years 1890–1900 Canadian chemical industry should enter its first marked period of expansion; it was in this period that some of the more important of our modern chemical engineering industries secured a firm foundation or had their origin.

The most outstanding feature of these years was the inauguration of electro-chemical processes based upon the hydro-electric energy made available for the first time. This led to the manufacture of phosphorus at Buckingham, utilizing the local phosphorus ore apatite. These operations, today greatly expanded, constitute one of our important chemical industries, although the phosphorus ore is now imported. It also led to the manufacture of calcium carbide at Niagara Falls in 1896.

Progress however was not limited to the electro-chemical field.

The Portland cement industry was founded in the early nineties replacing imported Portland cement.

In 1894 the commercial production of glucose from starch was undertaken at Cardinal, Ontario, one of the first instances in Canada of the revolutionary changes chemical engineering was to bring about in many of the older industries. Another development of the period was the firm establishment of the wood distillation industry and the production of acetic acid.

By the turn of the century we thus find a number of well established chemical industries and it is interesting to note how these industries had been built up around our natural resources.

An important professional development of the period was the gradual emergence of chemical engineering as a separate branch of the engineering profession. By 1900 courses in chemical engineering had been established at some of the American universities and the chemical engineer as distinguished from the chemist or mechanical engineer had become identified with the chemical and allied industries.

The period from 1900 to the outbreak of the war in 1914 was one of active and rapid development professionally

**Fig. 1—Sulphuric Acid Plant of Nichols Chemical Company, Capelton, Que. 1890**

*See Appendix.

Vessels and fractionating equipment of the combined topping and cracking plant at Shell Oil Company of Canada Limited refinery at Montreal East. This refinery was built in 1933.

*Illustration through the Courtesy of*
Shell Oil Company of Canada, Limited

and industrially. At this time the formation of the American Institute of Chemical Engineers and the Institution of Chemical Engineers of Great Britain definitely settled the status of the chemical engineer, and chemical engineering courses were established at our Canadian universities.

Industrial developments were numerous and it is again interesting to note how these were associated with our natural resources and involved newly discovered methods and processes.

In 1901 the manufacture of aluminum was undertaken, using the newly developed hydro-electric power at Shawinigan Falls. This was the beginning of one of our most important electro-chemical industries with a world wide market.

A few years later the Canada Carbide Company was formed to undertake the manufacture of calcium carbide also at Shawinigan, an electro-chemical development which was the forerunner of the important contemporary synthetic organic chemical industry for which Shawinigan Chemicals Limited is justly famous.

Electrolytic refining of lead was undertaken in 1904 at Trail, B.C.; the production of cobalt and arsenic compounds at Deloro, Ontario, followed shortly afterwards, utilizing the famed Cobalt silver ores.

The first cyanamid plant on the American continent was built and started operations at Niagara Falls, Ont., in 1909. This event is of particular interest as it represents one of the first answers of the chemical engineer to the old bogey of a world wide shortage of nitrogen fertilizers.

Other milestones of chemical engineering progress were the establishment of the first contact sulphuric acid plant in Canada at Sulphide in 1908, making use of locally mined iron pyrite, the installation of an electrolytic caustic soda and bleaching powder plant at Windsor in 1912, utilizing local salt deposits, the introduction of the revolutionary process of oil hydrogenation at Toronto in 1914.

It was also in this period that the petroleum industry entered that stage of expansion and technical development which was eventually to make it one of the greatest of chemical engineering industries.

These years were also marked by the generally increased application of chemical engineering methods to industry. There was substantial chemical engineering progress in such widely diversified industries as pulp and paper, vegetable and animal oils, textiles, and compressed gases.

The war period 1914–1918 imposed heavy responsibilities upon chemical engineering. Chemicals and explosives were required for military purposes on a previously unthought of scale and many metallurgical and chemical products heretofore imported had to be made in this country. Such wartime emergencies and demands afforded the chemical engineer opportunities of demonstrating his versatility and ingenuity and the flexibility of chemical industry.

Some developments were essentially of a wartime nature, such as the manufacture of cordite, nitro-cellulose powder, trinitrotoluene, etc., and were discontinued with the termination of the wartime demand. Others were of a fundamental nature and were to become a permanent part of our chemical engineering industries. The list is too long to cover in detail but certain accomplishments were of particular importance.

**Fig. 2—Canada Carbide Company Limited, Shawinigan Falls, Que. 1904.**

An outstanding achievement was the development at Shawinigan Falls of the processes by which acetylene was synthesized to acetic acid and acetone to supply much needed raw materials for aeroplane manufacture and explosives. By intensive research textbook reactions were developed to large scale production in record time.

Another outstanding achievement of this period was the research and plant development which led to the electrolytic production of zinc at the plant of the Consolidated Mining and Smelting Company at Trail, B.C. This process put into operation in 1916 has since been widely adopted elsewhere and has made possible the commercial production of the exceptionally pure zinc now widely used in the die casting industry. It was also in the same period and by the same organization that methods of differential flotation were applied to the highly complex ores of the Sullivan mine, a development of outstanding importance to Canada's mining industry.

**Fig. 3—Sarnia Refinery of Imperial Oil Company Limited. 1903.**

Fig. 4—Sarnia Refinery of Imperial Oil Company Limited. 1937.

Further important new activities were the refining of nickel at Port Colborne and the establishment of a magnesia refractory industry utilizing the magnesite deposits of the Calumet district.

In addition to such developments, heavy wartime demands also involved increased production of acids, large scale production of ferro alloys by electro-thermic methods and the production of metallic magnesium as well as many other products.

The rapid progress of chemical engineering industry during the war was a forcible demonstration of the national importance of chemical industry and aroused increased public interest. Much of the air of mystery which to the public mind pervaded chemical operations was dispelled. More particularly business men became familiar with chemical industry and learned to associate it with large industrial developments using raw materials on an extensive scale.

The close of the war brought a period of readjustment in which chemical engineering played an important part. It was necessary to develop new markets and new products to utilize wartime plants and organizations. The chemical engineer again demonstrated his ability to meet the needs of the situation.

Fig. 5—Sulphuric Acid Contact Plant, Canadian Industries Limited, Sudbury, Ont. 1936.

Chemical research was diverted from wartime problems into peaceful channels, resulting in new processes and new products. The chemical engineer rapidly transferred these from laboratory to plant and in this way many chemical industries which had undergone a mushroom growth during the war were re-established on a firm and sound industrial basis.

The period 1919-1929 was one of general industrial expansion and chemical engineering progress was rapid. The older chemical industries expanded and improved processes and products. At the same time they developed new products and processes.

New chemical industries were created, in some instances producing standard products from new raw materials and in others manufacturing entirely new products. Excellent examples are the synthetic ammonia plant utilizing the nitrogen of the air and the artificial silk industry manufacturing a new textile fibre.

Equally important was the penetration of chemical engineering into industry at large, resulting in the application of scientific methods to technical operations formerly carried out in an empirical manner. The recovery of waste products and their conversion into valuable by-products has been typical of chemical engineering activities in many of the older industries. There are now few industries which can afford to be without chemical engineering service.

Some of the developments of this period, 1919-1929, were as follows:—

In 1919 the manufacture of soda ash by the ammonia-soda process was undertaken at Amherstburg making use of the natural salt deposits of the district.

In 1922 a plant for the manufacture of liquid chlorine was installed at Windsor and in 1924 the manufacture of phosphoric acid from phosphorus was undertaken at Buckingham.

A spectacular chemical engineering development was the installation of the rayon plant at Cornwall in 1925.

The same year a contact sulphuric acid plant was installed at Coniston, Ont., utilizing waste smelter gases as a source of sulphur, thus converting a waste product and nuisance into a valuable product. It is significant of the times that although these waste gases had been available for many years it was not until 1925 that chemical engineering initiative and growing demand brought about this development.

By 1926 the world wide demand for aluminum had so increased that its manufacture was undertaken at Arvida, Que., on a large scale, utilizing the hydro-electric power available in the district. This additional aluminum capacity made Canada one of the world's largest producers.

In 1929 a sulphuric acid plant, utilizing waste smelter gases, and a synthetic ammonia plant were installed at Trail, B.C. in connection with large scale plans for fertilizer production. This development is of particular interest as it represents a profitable chemical engineering solution to the waste smelter gas problem at the Trail smelter.

Other important developments of the same year were the erection of a plant for the manufacture of cellulose acetate silk (celanese) at Drummondville, Que., the manufacture of synthetic ammonia at Windsor and the catalytic production of nitric acid from ammonia at Beloeil.

The growing penetration of chemical engineering into many industries has been referred to. While this trend was very general certain examples stand out prominently.

The great expansion of this period in the pulp and paper industry was accompanied by many chemical engineering improvements resulting in greater efficiency and improved products. Of great importance to the industry was the realization that pulp and paper processes were essentially chemical engineering processes.

In the petroleum industry application of chemical engineering technique revolutionized refining practice, introducing cracking processes and modern methods of distillation, thus greatly improving efficiency and the quality of the products.

Similar achievements in many industries served to further increase the prestige of the chemical engineer and by 1929 chemical engineering as a branch of the engineering profession had assumed a role of major importance.

There was a general realization of the necessity of science in industry and this recognition was being fostered by government agencies and other public bodies. Moreover, the highly technical requirements of the chemical and allied industries led to the rapid promotion of chemical engineers to operating and executive positions of importance.

With the onset of the depression in 1929 the chemical engineer again found opportunities of demonstrating his ability and versatility. It is noteworthy that even in the depression years the chemical industry continued to make progress, much of which resulted from the development of new products and new processes. Demands for economy and the pressure of competition also claimed attention and in the rebuilding of many industries chemical engineering played a predominant part.

Certain accomplishments of these depression years are of particular interest. In 1931 the Canada Cement Company Limited developed a special Portland cement to withstand the corrosive action of the alkali soils of western Canada, thus considerably enlarging the field of usefulness for this important material.

The recovery of metallic selenium from electrolytic copper slimes was first undertaken at Sudbury in 1931. In 1934 the large scale production of selenium and tellurium commenced at the Canadian Copper Refinery at Montreal East. Canada is now the leading world producer of these comparatively rare metals and it is significant of the trend of chemical industry that markets have developed as rapidly as these metals have become available.

In 1933 the production of radium and uranium salts from the pitch-blende silver ores of far northern Canada was undertaken commercially at Port Hope, Ontario, a matter of world wide interest as it represents a new source of these important and rare elements.

Another interesting development of the depression years was the erection of a cellophane plant at Shawinigan Falls.

Other recent advances have been the production of hydrogen peroxide, sulphur chloride, trichlorethylene, acetic anhydride and the recovery of liquid sulphur dioxide and elemental sulphur from waste smelter gases.

Current recovery from the depression finds the chemical engineering industries in a strong position with demand

**Fig. 6—Shawinigan Chemicals Limited, Shawinigan Falls, Que. 1936.**

taxing existing capacities. Many plans for expansion are being made.

Professionally, chemical engineering was never in higher repute than at the present time. Engineering courses at our universities are turning out chemical engineering graduates in numbers greater than in other branches of engineering. What slight unemployment existed in the profession during the depression has practically disappeared, with a shortage of trained chemical engineers and chemists in prospect.

Chemical engineers in Canada have no exclusive professional organization but are associated in professional matters with The Engineering Institute of Canada or the chemical societies of Canada. Many of them are also members of the American Institute of Chemical Engineers or the Institution of Chemical Engineers of Great Britain. It is to be hoped that further professional developments will continue to proceed within existing professional bodies.

It is difficult in a brief survey of this sort to convey an adequate conception of the progress that has been made in the last fifty years. Reference to Table I will give some idea of the tremendous growth of the chemical industries

**Fig. 7—Fertilizer and Chemical Plant, Consolidated Mining and Smelting Company, Trail, B.C. 1936.**

and their importance in the economic life of the country. Industries such as the pulp and paper industry and the petroleum industry of no importance fifty years ago have now become leading industries.

Even more significant of chemical engineering activities are the new industries which have been created, such as the electro-chemical industries and the organic chemical industry.

It is a well recognized fact that some of the finest fundamental research is carried out by industrial research organizations who recognize its value and necessity and who do not look for immediate financial returns from it.

Industrial research of a high order has been carried out in Canada by such companies as Consolidated Mining and Smelting Co. Limited, Imperial Oil Limited, Shawinigan Chemicals Limited, Canadian Industries

**Fig. 8—Explosives and Chemical Plant, Canadian Industries Limited, Beloeil, Que. 1936.**

Limited and others. The pulp and paper industry has accomplished much, both through co-operative research and also through the research departments of individual companies.

The technical progress involved in such operations is so remarkable as to be difficult to appreciate. The individual developments which go to make possible such a process as the manufacture of ammonia from hydrogen and the nitrogen of the air are numerous and complex. They have all been made effective in less than fifty years.

Much of the credit for the progress made must be given to the scientific worker in the research laboratory and the industrial laboratory whose fundamental scientific work has laid the foundation.

Chemical research in the broadest sense has of necessity gone hand in hand with the work of the chemical engineer, making available the information which has been translated into industry. Not only has it been necessary to develop in the laboratory the processes of modern chemical engineering industry but in many instances these processes demanded new types of equipment and new materials of construction which also had to be worked out in the laboratory.

Excellent examples are those chemical engineering industries requiring high pressures and high temperatures with close control of temperature and pressure. Without the development of new ferro alloys and automatic regulating devices these processes would be inoperative on an industrial scale.

Little resemblance exists between the apparatus in use fifty years ago and today. Older types of operation such as filtration, evaporation and distillation have been revolutionized by basic research and new materials of construction and new types of apparatus have been created utilizing new scientific principles.

It is consequently not surprising that research has become highly organized and a recognized function of the chemical engineering industries.

Industrial research organizations have been developed by industry, by universities and by Government institutions; actually there are few important industries which have not research facilities of some sort at their disposal.

Endowed industrial research as undertaken by the National Research Council, the Ontario Research Foundation and other Government departments has stimulated industrial research throughout industry, in addition to the important direct results obtained from it.

Canada also benefits substantially by industrial research carried out in the United States and Great Britain by industries with Canadian affiliations. The importance of such co-operative research is apparent in view of the large industrial research programmes carried out in the United States, it being estimated that in 1937 about $250,000,000 will be expended for this purpose.

What are the prospects for the future?

It is difficult to write of the progress of the past fifty years with a first hand knowledge of events and the men who made them possible without a feeling of great optimism as to the future. Just as chemical engineering has expanded in the past by making itself indispensable to the older industries and by creating new industries so it will develop in the future.

The intimate association between the natural resources of Canada and the development of the chemical engineering industries has already been pointed out. In the further exploitation of our natural resources chemical engineering is bound to assume an even more important role.

The motto of the chemical engineer might well be "To Learn is to Live." Chemical engineering has not stopped learning and it is far from a rash prophecy to predict a future of continued progress resulting in processes and products unknown today and destined to add greatly to our national well-being.

## APPENDIX

### Table I

Some Statistics of the Chemical Engineering Industries in Canada, 1890-1935

| | 1890 | 1935 |
|---|---|---|
| Abrasives, artificial | nil | $ 7,188,672 |
| Acids, alkalies and salts | $ 2,161,541 | 19,012,615 |
| Aluminum | nil | 9,200,000* |
| Breweries | 5,717,873 | 40,699,040 |
| Coke and gas | 2,886,697 | 38,474,789 |
| Distilleries | 2,199,600 | 16,114,361 |
| Dyeing and finishing of textiles | 345,504 | 4,004,734 |
| Explosives, ammunition, fireworks | 1,060,855 | 8,537,514 |
| Fertilizers | 280,829 | 6,075,616 |
| Gases, compressed | nil | 3,007,765 |
| Glass | 697,150 | 7,337,260 |
| Inks | 55,500 | 2,886,850 |
| Linseed oil and cake | 377,000 | 3,068,776 |
| Medicinals and pharmaceuticals | 789,400 | 21,292,751 |
| Paints, pigments and varnishes | 1,936,825 | 20,341,400 |
| Petroleum refining | 2,064,115 | 79,176,081 |
| Pulp and paper | 1,057,810 | 162,651,282 |
| Rubber goods | 2,059,320 | 55,949,570 |
| Silk, artificial | nil | 3,722,419* |
| Soap and washing compounds | 2,152,960 | 16,002,040 |
| Starch and glucose | 489,950 | 5,082,694 |
| Sugar refining | 17,127,100 | 36,597,997 |
| Tanneries | 11,422,860 | 20,497,553 |
| Waters, aerated | 946,715 | 13,851,785 |
| Wineries | 441,724 | 3,152,238 |

*Estimated.

The figures given are selling values at the plant and, with a few exceptions, have been obtained from the Department of Statistics, Ottawa.

### Table II

Chronological Table Showing Date of Establishment of Various Chemical Industries in Canada

Prior to 1885—
Sulphuric acid and nitric acid manufacture, nitro-glycerine, black powder, wood alcohol, brewing, distilling, soap, starch, sugar refining, tanning, etc.

1885—Sulphite pulp at Merritton, Ont.
1889—Portland cement at Hull, Que. and Napanee, Ont.
1894—Glucose at Cardinal, Ont.
1895—Chlorate of potash at Buckingham, Que.
1896—Calcium carbide at Merritton, Ont.
1897—Phosphorus by electro-thermic process at Buckingham, Que., utilizing Canadian apatite.
Establishment of petroleum refinery at Sarnia, Ont.
1899—Ferro-chrome at Buckingham, Que., utilizing Canadian chromite.
Acetic acid as a by-product of wood distillation.
1900—Carbon dioxide from Grecian magnesite.
1901—Aluminum at Shawinigan Falls.
Hydrochloric acid at Capelton, Que.
1902—First large sulphite pulp operation in Canada at Hawkesbury.
1904—Calcium carbide manufacture undertaken at Shawinigan Falls, Que.
Electrolytic lead refining at Trail, B.C.
1907—Production of arsenic and cobalt compounds from ores of the Cobalt district at Deloro, Ont.
Chemical engineering course established at the University of Toronto.
1908—First contact sulphuric acid plant in Canada at Sulphide, Ont.
1909—First cyanamid plant on the American continent at Niagara Falls, Ont.
Sulphuric acid plant at Barnett, B.C.
Manufacture of formaldehyde from wood alcohol.
1910—Manufacture of oxygen and nitrogen by liquefaction at Montreal.
Canadian magnesite used to replace Grecian magnesite in manufacture of carbon dioxide.
1912—Manufacture of electrolytic caustic soda and chloride of lime at Windsor, Ont.
Carbon dioxide by coke process at Toronto, Ont.
1914—Hydrogenation of vegetable oils at Toronto, Ont.
1916—Electrolytic refining of copper and zinc at Trail, B.C.
Manufacture of acetone and acetic acid from acetylene at Shawinigan Falls, Que.
Production of butyl alcohol and acetone by fermentation process at Toronto.
1917—Manufacture of cyanide at Niagara Falls, Ont.
1918—Production of refined nickel at Port Colborne.
1914-18—War period.
Manufacture of explosives, solvents, ferro-alloys, metallic magnesium, alloys, etc., for war purposes.
1919—Soda ash at Amherstburg.
1922—Liquid chlorine at Windsor, Ont.
1923—Acetylene black at Shawinigan Falls.
1924—Large scale production of nitro-cellulose lacquers for the paint trade.
1925—Manufacture of "Rayon" (viscose silk) at Cornwall, Ont.
Erection of contact sulphuric acid plant utilizing waste smelter gases at Coniston, Ont.
1926—Production of ethyl acetate and butyl acetate at Shawinigan Falls.
1928—Metallic cadmium at Trail, B.C.
1929—Manufacture of "Celanese" (cellulose acetate silk) at Drummondville, Que.
Manufacture of vinyl acetate resins at Shawinigan Falls.
Synthetic ammonia, sulphuric acid from smelter gases and ammonium sulphate at Trail.
Synthetic ammonia at Windsor.
Nitric acid from ammonia at Belœil.
1930—Portland cement resistant to western Canada alkaline soils.
1931—Selenium from electrolytic copper slimes at Sudbury.
1932—Phosphates of soda and lime at Buckingham.
"Cellophane" at Shawinigan Falls, Que.
1933—Radium and uranium salts from Canadian ores at Port Hope, Ont.
Nicotine sulphate manufactured at Montreal.
Sodium silicate at Niagara Falls, Ont., by electric furnace process.
1934—Selenium from electrolytic copper slimes at Montreal.
1935—Tellurium from electrolytic copper slimes at Montreal.
Hydrogen peroxide at Shawinigan Falls.
Elemental sulphur from waste smelter gases at Trail, B.C.
Electrolytic caustic soda and chlorine at Cornwall.
1936—Acetic anhydride and acetone from acetylene and steam at Shawinigan Falls.

# Urban Transportation

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"The streets of a city may be compared to the veins and arteries of the human body, especially if we include under the title of street not only the open right-of-way, but subways and elevated roads. So long as these function properly the community will be healthy. Nothing can take the place of good circulation in a city any more than in a human body."

R. L. Duffus.

Fifty years ago corresponds very nearly to the date of the discovery of electric street cars. In fact the decade beginning with 1880, was a period of pioneering in that field.

As early as 1884, Van Depoele ran an electric railway line at the Toronto Exhibition, 3,000 feet long, using an under-running trolley wire. This line was used until 1892 to facilitate access from the horse-car line of the Toronto Railway Company, to the exhibition grounds. It is claimed that this was the first, purely commercial adaptation of the electric railway in America. In June 1886, Van Depoele also operated a 1.2 mile line in Windsor, Ontario. The equipment consisted of two cars, each equipped with one 20 hp. motor. The current was collected as in Toronto, from an overhead wire with an under-running wheel, the return of the current being made through the rails. In 1887, the same engineer built and operated a line seven miles long in St. Catherine, Ontario, with two cars.

It is generally recognized that the first large commercial electric railway was built and operated by Frank J. Sprague in Richmond, Va., in 1888, and that its success was the foundation of the electric street railway. It was a complete installation, including eleven miles of track, overhead lines, generating station, and forty cars.

The Vancouver Street Railway Company, was organized in 1888 to construct and operate tracks in the city of Vancouver for horse-car operation, but before the initial work had been completed it was decided to change to electric traction, even though the stables for the horses had actually been built. Operation of the first electric railway lines in the city of Vancouver, totalling about six miles, was commenced on June 28th, 1890, and has continued ever since.

In the year 1891, through the energy and courage of two enterprising pioneers, Messrs. Ahearn and Soper, the Ottawa Electric Railway began operating electric cars on regular schedule in the city of Ottawa. On August 15th, 1892, the first electric car in Toronto was placed in service on Church street, and within the next two years, the whole system was electrified. On September 21st, 1892, the first electric cars were operated in the city of Montreal, around the belt line, via: Craig street, Park avenue, Mt. Royal avenue, St. Lawrence boulevard, Rachel street, Amherst street, to Craig and Côté streets. The city of Winnipeg also started to operate electric street cars during 1892—the city of Saint John, New Brunswick, in the year following—the city of Quebec, in 1897.

Thus the Canadian companies were amongst the first to adopt electric traction as a means of urban transport, and it is becoming here to pay tribute to the enterprising spirit of those pioneers, and also to the Canadian engineers of that time, who were responsible for its development in Canada.

## ROLLING EQUIPMENT

### Street Car Motors

The great difficulty with which the engineers in the early days had to contend, was to develop a motor suitable for car operation. Van Depoele's first motor was mounted on the platform of an existing horse-drawn car and belted to the axle of the car. It is said that it soon shook to pieces both the platform and the car itself.

Sprague, in 1886, was the first to develop the method of supporting one end of the motor on the axle and the other on the truck. The motors that he used in Richmond, Va., consisted of two 7½ hp. series-wound bi-polar motors per car. The motors were centred on the axles and geared at first by single and then by double reduction gearing. None of the manufacturing companies at that time were able to design a motor to run at the speed required for single reduction which would be small enough to be placed in the space available under the floor of the car and between the axles. As one may imagine, the motors of that time were a never-ending source of trouble, because they were of insufficient power, and were not protected against dust, mud and water.

The Westinghouse Electric Company entered the electric railway field in 1890, and brought out in 1891 their No. 3 motor, a four-pole slow speed motor with single reduction gears. While sturdy and reliable, the cast-iron frame and slow speed (about 385 r.p.m. at 10 miles per hour) made it quite heavy.

Fig. 1—Single Horse Car, Toronto. 1890.


Fig. 2—Vancouver Street Railway Cars. 1890.


MODERN car operated in Toronto, 47 feet long, and equipped with 4–35 H.P. motors.


MODERN car as used in Montreal.


ONE OF the new trolley buses recently put into service in Montreal.

TYPE OF bus used in Toronto on feeder routes to trunk rail lines.

THE PAST half century of engineering advance has seen the passing of the horse car with a few miles of travel and in its place the development of great systems with hundreds of miles of track and bus routes handling the transportation of hundreds of thousands of people, without which the growth of great cities could not have taken place.

*Illustrations through the Courtesy of the* TORONTO TRANSPORTATION COMMISSION *and* MONTREAL TRAMWAYS COMPANY

The Edison General Electric Company also brought out in the same year, a single reduction four-pole motor which was one of the best of its day. The design of single reduction motors marked a distinct improvement in the street railway motors of that time.

In 1892, the Thomson-Houston, Edison, Sprague, and a few other interests were combined to form the General Electric Company. All of the earlier lines of motors manufactured by the above mentioned concerns were abandoned, and were replaced by a new line of motors of which the GE-800 was typical. It was claimed at that time to be the lightest motor for a given output. Rated at 25 hp., its weight was 1,455 lb. The closing of this motor made it quite water and dust proof.

In 1894, the Westinghouse Company brought out their No. 12-A motor, completely enclosed, with the armature shortened and all bearings carried in the motor casing. This type of motor for 25 and 30 hp. ratings was standard for many years. During the years 1894 and 1895, the same company developed their 50 hp. motor No. 38 for larger output.

In 1895, the General Electric Company replaced their GE-800 motor by a new line, of which the 50 hp. GE-57 was the earliest.

These lines of motors, the Westinghouse 12-A and 38, and the GE-57 were typical of the revised design which embodied every essential for successful operation, and which continued practically standard for many years. They were enclosed motors, with frame made of steel casting, series connection of field and armature, ventilated armature windings, four poles and single reduction gearing.

It will be noted from the above that the period before 1890, might be called one of experimentation, and that from 1890 to 1895, one of development. The Canadian companies started to electrify their systems from the year 1890 onward, and used motors of the above types.

Series motors were adopted in preference to shunt motors as being especially applicable for work which demands large starting torque. In addition, the series motor has the very desirable characteristic that when a car ascends a grade, the motor will automatically slow down. The drop in speed allows the motor to develop a large torque with but a moderate increase in power. In the case of a shunt motor, it will maintain the speed of the car at approximately the same value that it has when the car is running on level ground; the motor, therefore, will tend to take an excessive current.

The next great improvement in railway motors came in the years 1907-1908, with the use of motors having commutating poles. These, placed between the main poles, and connected in series with the armature, had the effect of neutralizing the distortion of the main flux, and thereby greatly improving the commutation under any conditions of load.

About 1912, improved ventilation was obtained by the addition of a fan on the armature shaft inside the motor case to draw air through the motor. This method of self-ventilation practically doubled the continuous rating of enclosed motors. These features enabled the overall dimensions and weight of motors for a given rating to be reduced, thus permitting the use of smaller diameter wheels on cars, and at the same time lowering the height of the floor and of the steps; an improvement of decided advantage.

The curve in Fig. 3 shows the weight per horse power for different classes of motors used from 1892 to 1936. The weight is that of the motor and the pinion only, and does not include the gear and gear case. It indicates, that for motors of conventional design operating at about 600 volts with single reduction gears, the weight has been reduced from 80 lb. to 32 lb. per hp. The normal speed (one hour rating) has been increased from 500 r.p.m. to 1,000 r.p.m.

During recent years important development has been made in the design of so-called high speed motors. They are designed for 300 volts for better performance, two motors being permanently connected in series for the 600-volt circuit. On the new cars of the type recommended by the Presidents' Conference Committee (to which

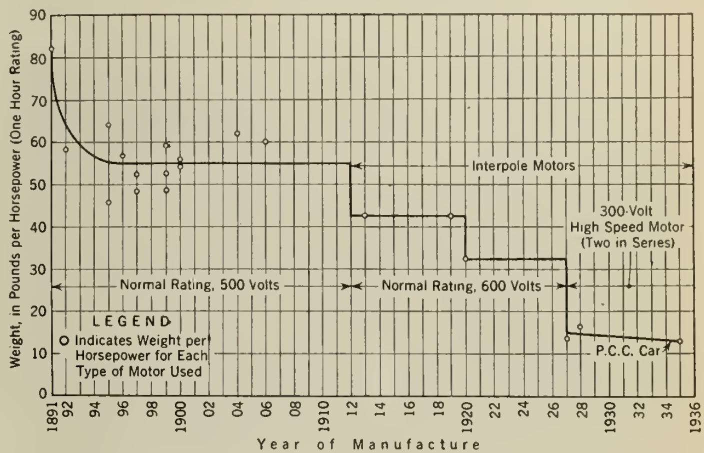


**Fig. 3—Curve Showing Trend in Weight of Street Railway Motors.**

reference will be made later) the motors have a one-hour rating of 55 hp. The weight complete with drive flange varies from 700 to 725 lb. which is about 13 lb. per hp. When this is compared with the 75 lb. per hp. of the year 1892, the progress that has been made in the design of street railway motors can be appreciated.

### Street Car Bodies

The type of body, used at first was that of the horse-car; in fact in some cases the motors were applied direct to the original horse-car bodies. This arrangement did not prove satisfactory. Two types of car soon became of general use. These were the four-wheeled single truck closed car, having longitudinal seats, and the single truck open car, fitted with cross benches and outside longitudinal steps for summer use. The protection offered by closed and heated cars was a necessity in winter, but the popularity of the open car was so marked that it was the usual practice to have two sets of car bodies for each equipment of trucks and motors. These cars measured about 30 feet overall in length, and weighed about 18,000 lb. The motor equipment usually consisted of two 25-hp. series motors. The bodies themselves were practically all wood contruction. The cars were heated by stoves burning coal. Another type of car used was the "convertible car" with removable side panels, making it possible to change these car bodies to the open type in summer, and the closed type in winter.

About 1900, traffic conditions in the central part of the larger cities pointed towards the development of larger cars so as to decrease the number of car units. At about that time the use of the open car was being discouraged, and it was later finally prohibited by various provincial public utility boards.

With the increase in carrying capacity, length and weight of car, the use of the single truck was no longer practical. It was replaced by two trucks with shorter wheel base on which the longer car body rested on pivoted centres. Double truck closed cars were built about 1901, and weighed some 35,000 lb. Then in 1904, the pay-as-you-enter type of car was developed and first used in Montreal. It weighed about 47,700 pounds, and its use quickly spread over the whole continent. Its principal feature was that it allowed, without undue delay at loading points, for the collection of fares at the rear end of the car. The conductor was then able to supervise the movement of passengers, on and off the rear steps, and the reduction in accidents was very marked. The rear end platform was open in those days. The front end was closed and the movement of passengers getting off at that end was under the direct control of the motorman.

Heating by the use of electric current, in place of stoves, was adopted at that time.

It will be noted from the above that the weight of the city cars increased very rapidly from the single truck

**Fig. 4—Street Car Service in Toronto. 1905.**

car of 1901, weighing about 18,000 lb., to the double truck car of 1905, which weighed some 48,000 lb. The weight continued to increase up to about the year 1910, when some of the cars built during that period weighed as much as 56,000 lb. A curve has been drawn showing the trend in weight of cars used in the city of Montreal from 1892 to date. In determining the curve shown in Fig. 6 the weight of cars operating in city streets only was taken, suburban cars and trailers were left out.

The tendency about 1910, was toward cars of large capacity with heavy equipment. These were favoured because of better tractive possibilities on snow covered rails, and because they provided a large margin of inherent heat capacity to meet heavy current demand of operation during heavy snow storms.

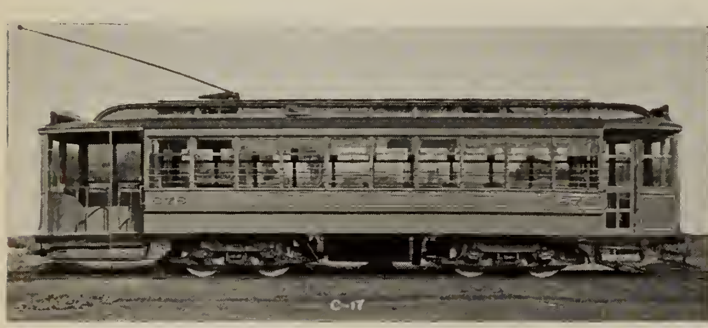

**Fig. 5—First Pay-as-You-Enter Car in Montreal. 1904.**

Beginning in 1907, in Montreal, all the underframes of cars purchased were made of steel up to the window sill. Posts and roof carlins were of composite construction of wood and steel; the roof and the floor were of wood. Some of these cars built at the end of 1907, were 50 ft. 6 in. long, and 8 ft. 9¾ in. wide. Their weight was 56,600 pounds, divided thus: body 29,900 lb., trucks 15,500 lb., equipment 11,200 lb. They were the largest city cars built for that city. Between the years 1910-1915, the car length was reduced to 46 ft. 8½ in. overall, and the width to 8 ft. 4½ in., which is very near the length and width of the two-man cars of to-day. The weight dropped to about 46,000 lb. All of the above cars were equipped with four motors of capacity varying from 40- to 50-hp. each.

During 1914, the use of two-car trains was first tried in Montreal. Twenty-five motor cars, weighing 43,600 lb., and equipped with four 53-hp. motors, were coupled with 25 trailer cars without motors. The trailers weighed 27,400 lb. These were the first cars built with totally enclosed vestibules, and proved to be of real value during rush hours on streets of heavy traffic, and where the headways between cars was short. It was found, however, that these trains were deficient in power capacity and could be operated satisfactorily only on streets where the grade did not exceed six per cent. For that reason, in the next lot of fifty cars and fifty trailers built in 1917, the motor cars were equipped with four motors, 53 hp. each, and the trailers with two motors of the same capacity. The control was of the P.K. multiple unit control type 12 volts, and the cars were equipped with air operated doors. These trains were satisfactory on grades up to 12 per cent.

The above described pay-as-you-enter two-man cars had rear platforms with room for a large number of passengers to board the car, allowing for the collection of fares while the car was in motion, thus preventing delay at busy transfer points. From this idea, the "Peter Witt" type of

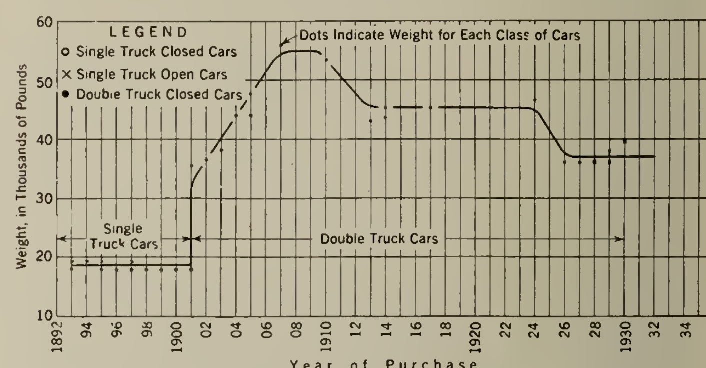


**Fig. 6—Curve Showing Trend in Weight of Street Cars.**

cars was developed. They may be described as front-entrance centre-exit pay-as-you-pass cars. Passengers enter a wide door at the front end without interference from descending passengers. The conductor is at about the centre of the car where two doors are located. He collects the fares of, and issues transfers to, passengers who wish to enter the rear or "paid space in the car"; they are free to leave at any time by one of the exit doors. Those remaining in the front part of the car pay their fare as they pass the conductor when leaving by the exit door immediately next to him. Suitable railings are provided to direct all movements in the desired direction.

This car offers great convenience in case of a large crowd entering a car. On the other hand, it is at a disadvantage when passengers leave the car in large numbers, as all those who remained in the front part of the car have to pay their fare before leaving. In practice it is very difficult to persuade the passengers that it is better for speedy operation not to stay in the unpaid area of the car. Another disadvantage is the opportunity it gives for the abuse of transfer privileges, because the conductor cannot judge when collecting a transfer if the passenger was entitled to its use at the time and place of his entry.

The "Peter Witt" type of car was favoured by a large number of companies on the continent and was adopted in Toronto in 1921.

During 1921-22-23, two hundred and fifty two-man cars of that type were purchased. They were steel frame cars weighing from 47,200 to 50,000 lb. An additional one hundred two-man cars of the same type were also purchased in 1922, but were about 4 ft. shorter than the standard ones. Their weight was 39,700 lb. They have since been transformed into one-man cars.

A large proportion of the new Toronto motor cars were equipped to haul 50 ft. trailers during rush hour periods. One hundred and ninety-five of these trailers were purchased during the period 1921-23. Thirty of them had two centre doors, and weighed 28,600 lb., one hundred and sixty-five had three doors, and were lighter, their weight being only 26,800 lb., all of which had no motor.

During the great war, an interesting development in car design had been made in the United States, with the introduction of what is called the "Birney Safety Car." The object had been to design a single truck car as light as possible, and equipped with the necessary safety measures to permit its operation by only one man. Economy in operation was the main object. Its weight was about 16,500 lb. It served its purposes well, and was valuable to many companies operating in small cities. It was less useful in large cities on account of its small size, except in a few instances, where stub service had to be provided in thinly populated districts.

Its influence, however, was considerable as it led to the development of the one-man car of to-day. It also directed the design of new cars toward a reduction of weight with the object of reducing operating cost.

Another important factor in the development of car design was the increasing use of the private automobile in city streets. The public demand was for speed in transportation and cars had to be built to keep pace in traffic with the automobile. This meant lighter cars, with quick acceleration and deceleration. Fortunately, the development of high speed motors, made possible a reduction in the size of the wheels from 33 in. diameter, to 30 in., and finally to 26 in. diameter by the year 1926. The result was that from that date, two-man cars of standard length could be built weighing only 36,000 lb.

During the years 1927-28-29, one hundred and forty two-man cars of the most modern type were built for the Montreal Tramways Company. Their overall length was 46 ft., their width 8 ft. 3 in., and their weight 36,000 lb. They were equipped each with four 42 hp. 600-volt series-motors with normal speed (one hour rating) of 1,045 r.p.m., and had single reduction gearing. The wheel diameter was 26 in., and they were of all steel construction except for the roof sheeting and the floor.

An important development in urban transportation was brought about by the introduction of one-man car operation. This demanded certain safety features which had not been previously considered necessary for two-man car operation. These included the use of power-operated doors with automatic treadle door exits, and additional precautions such as the dead-man handle, and interlock between doors, brakes and power.

The results of these safety appliances have been very gratifying. The records of accidents of all companies on this continent operating both one-man and two-man cars show fewer accidents per mile run in the case of the one-man car. This decrease in the rate of accidents must be attributed to causes other than mechanical, because in that respect both types of car are equally safe. Outside of a few additional safety appliances and necessary interlocking of power and doors, one-man cars are built exactly along the same lines as two-man cars.

### Brakes

Hand operated brakes of the ratchet type were quite satisfactory for controlling light single truck cars, but when car bodies and equipment increased rapidly in weight, some more powerful and quicker acting form of brake became necessary. Air brakes were, by that time, in common use on steam railways and their application to street cars involved no difficulty. The system first used was what is known as "straight air" in which the air application is made to the brake cylinder from the reservoir through the motorman's valve and is exhausted through the same medium.

Fig. 7—"Peter Witt" Car Built in 1921. Toronto.

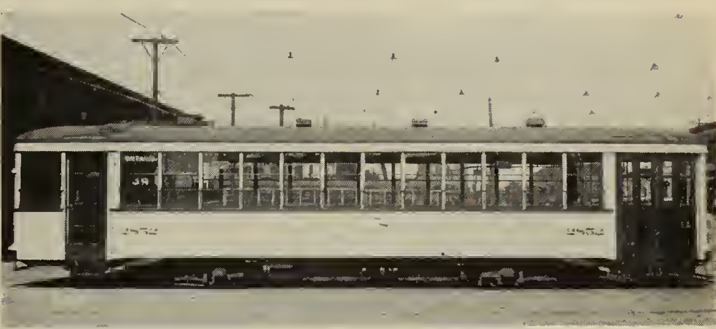

Fig. 8—One-Man Car Built in 1929. Montreal.

The simple straight air brake equipment was standard on all cars until the development of two-car trains. These required the simultaneous application of brakes on both cars in cases of emergency and, furthermore, it was essential that emergency brake application be made in both cars in case of a draw-bar failure.

The Westinghouse S.M.E. system was adopted. This operates as a straight air brake for all mild service applications, but a separate emergency air line is added for the purpose of providing synchronized brake applications on both cars when the air pressure in this emergency line is depleted through a special port in the brake valve or, automatically, in case of accidental separation of the two units.

This same system, slightly modified, has been applied to all single units built since that time, both one-man and two-man cars.

An interesting feature of the newer installations is the Form "E" relay valve. This device obviates the necessity of passing the air through the long pipe line from the reservoir through the brake valve to the air cylinder. The admission of a very small volume of air to the brake pipe acts on a small piston in this relay valve to open a direct connection between reservoir and cylinder. As soon as the air pressure in the cylinder balances with the pressure in the air pipe, the connection is shut off. Any degree of air pressure can thus be obtained in the air cylinder by passing a very small volume of air through the brake valve. Instantaneous release is effected in the same way.

All emergency actions result in the application of sand to the rail, the shortest possible stop being thereby attained.

### Control

A car is started by first impressing a low voltage upon its motors, and then gradually increasing the voltage as the motors speed up until they receive their rated voltage. Hence resistance must be connected in series with the motor armature and is gradually cut out as the armature


**Fig. 9—Two-Car Train. Vancouver.**

comes up to speed and develops a back electromotive force. This operation is performed by what is called a "controller."

As the average current input to each motor during the starting period is usually of the order of the rated current, a considerable loss of energy occurs during the period of acceleration of a car. The efficiency in the case of plain rheostatic control does not exceed fifty per cent. In order to reduce this loss the "series-parallel" method of starting was adopted in the very early days of electric traction, and has continued in use ever since. Its efficiency is 66⅔ per cent.

In the case of a car equipped with four motors, the motors are first divided in two groups, each group consisting of two motors which are always in parallel with each other. In starting, the two groups are connected in series, and also in series with the resistance. The resistance is then reduced step by step until the groups are alone in series across the circuit from trolley pole to ground, each receiving one-half of the line voltage. The motors then run at half their rated speed. When it is desired to further increase the speed, the groups are thrown in parallel with each other and a resistance again introduced. This resistance is then gradually cut-out until the last notch of the controller is reached when each motor receives full line voltage and runs at full speed.

There are two general methods of making the transition from series to parallel connections in series-parallel control. One, Type L, which opens the power circuit during the transition is little used. The other, Type K, does not open the power circuit, but is arranged to cut the current off half the motors during transition from series to parallel. This type has been used almost exclusively in Canada. In it, the main motor-current passes through the controller, which originally had only one blow-out coil to extinguish the arc formed between fingers and sectors as the circuits were opened. About 1910, a radical improvement was made by providing individual blow-out coils, these being fitted to the finger bases of each of the main fingers. With other changes, this improved type is the standard of to-day.

Power-operated control has also been developed, and in general, consists of two parts. There is first, a series-parallel motor controller composed of a number of circuit-breakers, sometimes called contactors, whose function is to effect the different combinations of the motors and regulate the starting resistances in circuit with them. This motor-controller is generally mounted under the floor of the car. Second, there is a master controller located in the vestibule of the car, and operated by the motorman. Its function is to actuate the motor controlling contactors. The current required to operate the master controller is small and ordinarily of the order of two to three amperes per car.

In one system of power-operated control, the motor-controlling contactors are operated electrically by the line current, while in another, the contactors are closed by compressed air and opened by a spring.

The advantages of the power-operated control may be summarized as follows:

(*a*) Multiple-unit train operation is made practicable.
(*b*) All circuit-breakers and other controlling devices which carry the main current motor are removed from the platform and placed beneath the floor of the car.

Power-operated control may be hand-operated when it is wholly under the control of the operator, or automatic, when the control is effected by current-limiting relays and interlocks on the contactors or unit switch.

Such automatic control of the car or of the train, as the case may be, eliminates the variable personal element in the handling of the controller which often results in uneven acceleration. Its disadvantages are that the cost of installation is high, and also that it is difficult to set the limit relay so that the car will be accelerated at the proper rate on different grades, and also under different conditions of track, car loading and street traffic density.

An important development in automatic control was made some eight years ago with the introduction of variable automatic control. (Type VA control).

The essential features of this new type are:
Automatic notching.
Slow, moderate and fast "pick up."
Hold, series and parallel position.

**Fig. 10—Toronto Transportation Company's Hillcrest Car Shops and Davenport Garage.**

In this controller, a variable rate of acceleration is obtained, which is proportional to the advance of the controller. This provides the flexibility so necessary when operating over the typical city route, since the rate of acceleration can be varied in order to conform to the street requirements.

The Montreal Tramways Company was one of the first properties on the continent to make use of the new type of control. Fifty new cars equipped with the variable automatic control were placed in service during 1930.

### The P.C.C. Car

As already stated, the past fifteen years have seen developments in transportation facilities, which have resulted in decided changes in the use of city streets. The private use of automobiles has increased beyond all expectation. The motor bus, and lately, the trolley bus, have definitely taken their place as modern vehicles of transportation.

In view of the above, a committee called The Presidents' Conference Committee was organized in December 1929, through the initiative of the American Transit Association and consisted of representatives of most of the large electric street railway companies in both the United States and Canada.

The object was: "the co-ordinating of efforts toward accelerating and furthering the technical development of the urban railway car and of the apparatus and equipment therein installed, to the end, among other things, that the rates of acceleration and deceleration of said car shall be quickened or improved as much as may be possible; that the car may be made as nearly noiseless as possible in operation; that the weight of the car may be reduced; and that the cost of operation thereof may be as low as possible and that a substantial reduction in the first cost of new cars may be achieved."

The Committee under the guidance of C. F. Hirshfeld, head of the research department of the Detroit Edison Company, who was selected as chief engineer for the Committee, spent four years in research and experimental work of all kinds. Three quarters of a million dollars were expended in designing, experimenting, and building equipment. In 1933, a new car called the Presidents' Conference Car (P.C.C. Car) was introduced, and its performance surpassed that of any previous car.

Four outstanding developments were accomplished:

(*a*) A new type of rubber sprung truck.

(*b*) A new type of rubber-cushioned wheels, also designated "resilient wheels."

(*c*) A motor of greater power and of very high speed, also a radically new control and braking apparatus for smooth rapid starting and stopping.

(*d*) An attractive and modernized car body.

The specification for the P.C.C. cars has been generally accepted as the basis of design for cars built to-day.

Over two hundred cars of the P.C.C. type were ordered during 1936 for Brooklyn, Chicago, Baltimore and a few other American cities. Some of these are presently in service.

A brief description of the main features of these P.C.C. cars, is as follows:—

In general the P.C.C. car is a light weight, four motor, double truck city car, with front entrance and centre exit.

| | |
|---|---|
| Length overall | 46 ft. 0 in. |
| Width overall | 8 ft. 4 in. |
| Wheel diameter | 25 in. |
| Total weight, empty | 33,350 lb. |
| Average accelerating rate (in miles per hour per second) | 4 m.p.h.p.s. |
| Maximum accelerating rate | 4.75 m.p.h.p.s. |
| Service braking rate | 4.75 m.p.h.p.s. |
| Maximum braking rate | 9.00 m.p.h.p.s. |
| Balancing speed in level track | 42 m.p.h. |

**Fig. 11—New P.C.C. Car Built for Brooklyn, N.Y. 1936.**

The average rate of acceleration is more than twice that of the present conventional street car, and substantially greater than that of the ordinary automobile. The service braking rate is also twice that of the present conventional street car.

Experiments made during the research work of the Presidents' Conference Committee show that these rates are well within the limits of human tolerance so long as they are accomplished without jerking or sudden changes in rate.

*Motors*

Special light weight motors were designed for these cars by both the Westinghouse Company and the General Electric Company. Both types, the GE-1198 and the Westinghouse 1432 are designed for 300 volts and are connected permanently two in series for the 600-volt circuit. This is a departure from the conventional 600-volt motor. The high speed motor does not differ fundamentally from that of the conventional type. It is so small, however, that 300-volt design provides better performance than 600-volt design. With the small commutator, the distance between brush holders becomes so short that the motor tends to become more sensitive to flashing, and the voltage to be commutated is also less. Commutator bars are larger and more substantial, and the armature conductor size is doubled by the use of 300 volts. The one-hour rating is 55 hp., or 156 amp. at 300 volts with 120 deg. C. temperature rise (resistance method); speed 1,670 r.p.m. The motor is self ventilated. The continuous rating is 135 amp. at 300 volts with 105 deg. C. rise, speed 1,820 r.p.m. The gear ratio is 7.17 to 1. The weight complete with drive flange varies from 695 to 725 lb. The outside diameter is 15¾ in. The motors are mounted longitudinally for a right angle drive. Transmission is of the right angle hypoid type, which is a special type of spiral bevel gear used in high grade passenger automobiles, and noted for its quietness.

No existing control system was considered capable of providing the smooth and rapid acceleration required for the new car. Both electrical manufacturers produced equipment along entirely new lines. It was considered essential to greatly increase the number of contacts in the controller, and to govern their action automatically. The saving of energy with series-parallel control was considered to be far overbalanced by its complication and the difficulty of obtaining uniform acceleration. The control adopted, therefore is rheostatic, with additional speed points obtained by shunting the motor fields. It is selectively automatic, that is, it produces automatically the performance called for by the position of the operator's control pedal. Unlimited selection of any accelerating rate between 1.5 to 4.75 miles per hour per second can be obtained. There is a switching position for slow movement. The operation of control is by means of a rocking or angle movement foot pedal operated with the right foot.

**Fig. 12—First Gasoline Bus in Montreal. 1920.**

*Braking*

Stopping is effected by a combination of dynamic, magnetic track and air brakes which are brought into action automatically, depending on the depression of the brake pedal. For dynamic braking the motors are used as generators. They are disconnected from the line and short-circuited through resistances, thus generating current by absorbing the energy of the car. The motor field is initially excited by a low voltage battery, and braking is therefore independent of the trolley line.

The magnetic track brake has four shoes, each 42 in. long, and hung between each pair of wheels. When energized they are pulled down to the rail by their own magnetism. The brake shoe itself is an electromagnet energized by a single coil designed for 32-volt current. Each shoe takes some 10 amperes when all resistance is cut out. The track brake is also independent of the trolley wire.

The air brake has four separate cylinders and lever systems, one for each axle, doing away with foundation brake rigging.

The complete operation of the brakes is as follows:—In service braking, as the pedal is depressed the dynamic brake comes into action first and will decelerate the car until the speed falls to about five miles per hour, when the dynamic brake fades out. At this point, the air brake cuts in and completes the stop, in conjunction with the track brake if the pedal is depressed enough to bring it in. The air brake is always available to hold the car. It will be noticed that under normal service conditions, the air brake is relieved by the dynamic braking of the motor of most of the work of the braking operation, and it comes into action only when the car has slowed down to five miles per hour. This arrangement greatly reduces the friction on the car wheels, which must be kept relatively cool to prevent the deterioration of the rubber. It also has the advantage of practically eliminating the skidding of the wheels.

Should an emergency arise, full depression of the pedal causes joint action of all three brakes regardless of the speed, bringing the car to rest in minimum distance.

*Truck and Wheels*

The design of the trucks and wheels differs in practically all essential respects from that used up to the present time.

Rubber was selected instead of steel for all springing. Rubber springs are very effective against high frequency impulses, and also as a noise insulator. Truck springs are made of rubber and steel, so arranged that the metal holds the rubber in place and transmits forces to it. The rubber serves as the resilient member.

The truck is as light as possible consistent with requisite strength. The side frames are two seamless steel tubes of 6¼-in. diameter with ⅜-in. wall. The cross members and supporting brackets are vanadium steel castings all electrically welded to the side tubes.

The resilient wheel, 25 in. in diameter, has a rolled steel web which carries the tread and rim, two outer circular steel plates (one on either side of the web), with disks of rubber held in compression between them and the hub. The construction provides for clamping these rubber disks in such a way that both radial and tangential forces are transmitted to the hub through the rubber.

*Body*

All welded construction is the outstanding feature of the construction of the body, which is light and very attractive in appearance. An alloy steel of high yield point is used in the body underframe, and copper bearing steel in the remainder of the structure. Research indicated that one of the causes of bad riding of the older street car was the high point of attachment between the car body and the truck. Consequently, the design of the new car has


**Fig. 13—29-Passenger Bus. Vancouver.**

been so arranged that the point of attack of the horizontal forces is only 11 in. above the rail.

Lighting has received particular attention. In the Brooklyn cars, luminator lensed globes are mounted one over each seat. Thirty-volt bulbs, 20 in series, give an intensity of 15 foot candles of light on a 45 deg. reading plane, 33 in. above the floor.

### Gasoline Buses

The use of motorbuses by electric railway systems began about 1920. In those early days, the bus consisted of truck chassis running on hard tire wheels, on which were mounted bodies designed for passenger service. This resulted in a vehicle having its floor quite high above the roadway causing inconvienence in riding, loading and unloading of passengers. Four solid tire motorbuses of the "charabanc" type were introduced in Toronto in 1921. A service was also established in Montreal about 1920, on Bridge street, where a small bus of the closed type was used. A second line was established in 1922, to serve streets along the harbour, the service being given by two small buses of the open type with cross benches.

These buses were not satisfactory for city service. It was soon realized that what was required was a bus having a low centre of gravity with floor as low as possible. Safety, comfort in riding, ease in boarding and alighting of passengers could not be obtained otherwise. The use of solid tires had also to be abandoned. A real effort was then made to design a bus to meet these requirements. As was the case in the automobile industry, the development of the bus during the last fifteen years has been really remarkable.

About 1925, Canadian electric railway companies decided that a point had been reached at which they could use buses to advantage. They were all of the closed type, with entrance and exit at the front, capacity varying from twenty-one to twenty-nine seats, and practically all were equipped with six-cylinder engines. Some of the smaller buses were equipped with four-cylinder engines, but it was found that these were subjected to such driving abuses, that the vibration was quickly damaging the chassis. Six-cylinder engines soon became general practice.

With the increase in the use of buses in large cities, traffic developed, and buses of larger capacity were required. Buses of the conventional type, with engine and hood, increased in size and soon reached an overall length of 32 ft.

With buses of this size, the engine became quite large, and it was realized that the space it occupied at the front end of the bus, was wasted as far as floor area was concerned. Buses were then built with the engine underneath the floor, or at the rear end underneath the rear cross bench. Another radical change was also effected some ten years ago, when a chassisless type of bus was brought out. The body and chassis, were built integral as one unit. The "Metropolitan" type or as it is also called the "Transit" type of buses for city service was thus introduced, and is the only type built to-day for city service.

The adoption of the above mentioned type of bus made possible a substantial increase in carrying capacity. Buses of thirty-six, forty and forty-two seats, with a fair amount of standee capacity are now built. The overall length for 36 passenger seating capacity buses varies from 31 ft. 6 in. to 32 ft. 6 in., depending on the position of the engine. That of the 42 passenger seating capacity with engine located under the floor is about 33 ft.

Fifteen years ago, no one would have believed that it would become practicable to drive a steered vehicle of that length in the congested streets of our large cities, especially when they have to go around parked or slow moving vehicles, and draw near the curb to load and unload passengers.

Six-cylinder engines are still generally used on the large buses. Their maximum capacity varies from 130 to 180 hp. The White Company of Cleveland, Ohio, has developed a twelve-cylinder horizontal opposed engine (six cylinders on each side of the shaft), called the twelve-cylinder "Pancake" engine, which is located under the floor of the bus.

The remarkable improvements in bus design, together with improved methods for maintenance have considerably increased the life of the modern bus. A first class bus to-day can run in city service at least 400,000 miles. The basis of depreciation is generally taken at eight years, but a bus is still useful for a few years after on secondary or emergency service.

### Oil Engine Buses

In the Diesel type of engine, the air is compressed in the cylinders to a high pressure, of the order of 500 to 700 lb. per square inch, thereby raising its temperature to a point where it is more than sufficient to ignite the fuel which is sprayed into the cylinder.

Engines of this type have been known for a long time, but as heavy slow speed engines they were not applicable to automotive work.

The development of a Diesel engine of low weight and high speed, suitable for use in buses and trucks, started some ten years ago. An engine was soon developed whose weight was not much above that of the gasoline engine, and of speed varying from 1,800 to 2,400 r.p.m.

**Fig. 14—36-Passenger Gas Bus, Transit Type. Montreal. 1936.**

On account of their fuel economy oil engines of the Diesel type are used to a great extent in Europe. Buses equipped with these engines are numerous in Great Britain. In London, where they have the largest fleet of buses in operation in the world, all new bus engines since 1934, have been of the Diesel type.

A bus equipped with this type of engine will run about twice as many miles per gallon as one equipped with the present gasoline engine. As fuel oil is cheaper than gasoline, the economy in fuel cost is still greater.

The Montreal Tramways were the first on this continent to install the Diesel engine on their buses. In December 1932, one bus was equipped as an experiment. The results obtained were good, and in 1935, fifteen buses were fitted with Diesel engines of English make.

Results to date have been satisfactory, with a saving in fuel cost, at current prices, of from two to two and one-half cents per mile. Indications are that maintenance will be no higher than that of the gasoline engine. Buses equipped with Diesel engines have also been used in Vancouver, where a somewhat greater saving was obtained than in Montreal; due to the greater difference between the cost of oil and gasoline.

It may be of interest to mention that in the United States, urban transportation companies started last year to equip buses for city service with engines of the Diesel type.

### Trolleybuses

The body and chassis of the trolleybus is that of the gas bus of the metropolitan type, but it is driven by an electric motor taking current from a positive trolley wire, like a street car. As there are no tracks to serve as return conductor there must be a second trolley wire, and consequently two trolley poles are required. The trolleybus is not obliged to travel in a fixed direction as a street car, since it can move at will, right or left, to a distance of 12 feet each side of the trolley wires. On streets of ordinary width it can, therefore, move as freely as an ordinary gas bus, and draw to the curb to load and unload passengers.

The principle of the trolleybus has been known in Europe for a long time. As far back as 1899, Siemens and

Halske experimented with one in Berlin. In 1900, Mr. Lombard Gérin built an experimental line 3,000 ft. long along the Seine, just outside the limits of Paris; and also in the Vincennes Park during the Paris Exhibition. A notable installation was also made in the Biela Valley, Germany, in 1901. It had an overhead structure very similar to that used to-day, and the vehicle had two separate trolley poles with shoes for current collection. Several other early trolleybus lines were also experimented with in England, and in the United States. In Canada, two small lines were operated for a short time, fifteen years ago, in Toronto and Windsor, Ont. The Toronto Transportation Commission placed four vehicles in service, and in Windsor a four-vehicle system was operated over two routes.

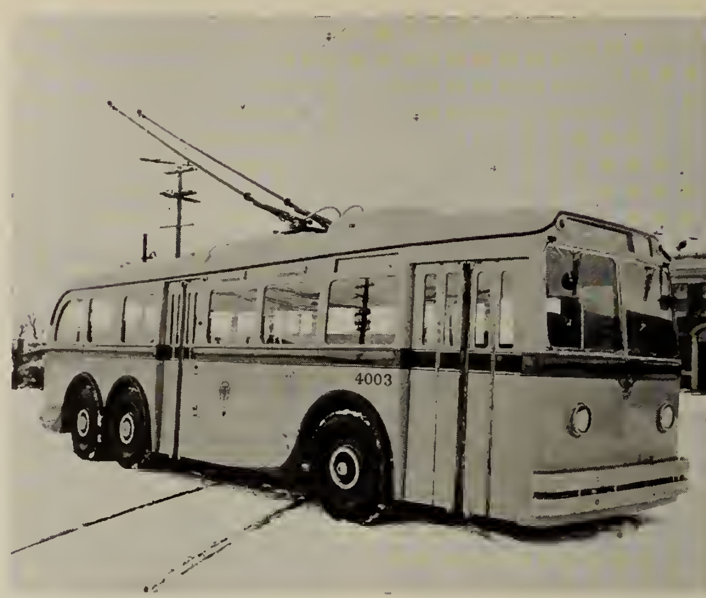


Fig. 15—40-Passenger Trolleybus, Montreal. 1937.

At that time the vehicle consisted of an ordinary four wheel omnibus with hard rubber tires, driven by an electric motor, and collecting its current through two trolley poles.

What was really lacking, was a chassis and body properly designed to suit mass transportation. The great improvements made along these lines for the gasoline bus were to be responsible for the renewal of interest in the trolleybus. In fact the modifications of design in 1928 and the years following have been so revolutionary that the trolley bus can now properly be termed a modern unit of transportation.

Its success and popularity for the last few years have been great, especially in Great Britain and in the United States. Canada's first modern trolleybus line was inaugurated in Montreal, March 22nd, 1937, giving a cross-town service on a street of medium traffic. Seven trolley buses, 40-passenger size, have been purchased in England by the Montreal Tramways Company.

These are single-deck, three axles, the two rear wheels being arranged in tandem, 40-seat capacity. They measure 32 feet in length over bumpers and the width over side sheeting is 8 feet. The wheel base is 16 ft. 2 in., and the weight 17,700 lb.

The bodies are of the all-metal type. The design is such that the riveted constructional sheets and members form the inner skin. The exterior sides and ends are sheeted with aluminum sheets secured in position by wood screws, and may be repaired or replaced easily. The roof carlins are of high tensile aluminum channel-section, and the roof is sheeted with aluminum. Insulation against cold is provided in the body and roof by the insertion of aluminum foil between the inner and outer panels.

The front entrance door has a clear width of 46 in.; the centre exit door is 26 in. wide and is fitted with low voltage treadle plate.

The frame is built up of nickel steel side members, section eleven by three inches, flitched over front and rear axle and down-swept at front to provide single step front platform. Three differentials are provided, ensuring equal distribution of driving torque to all four wheels of the rear bogie. Compressed air braking operates on all six wheels.

The power equipment consists of one compound-wound motor, 80 hp., 550/600 volts. Provision is made for regenerative braking, which though now first used in North America, is used almost universally in Great Britain. When the motor is running at speed, without resistance in circuit, it is generating a back E.M.F. nearly equal to the line voltage. With constant speed any increase in field strength will raise the back E.M.F. above the line voltage, and return current to the line. When the driver allows his master controller to return one or more notches, the corresponding shunt field contactors close and strengthen the shunt field. The motor voltage tends to rise, current is returned to the line, and the energy generated retards the vehicle. As the field falls, continued backward movement of the master controller pedal increases the strength of the motor shunt field step by step, and keeps the generated E.M.F. above the line voltage until the speed is reduced to approximately twelve miles per hour, at which speed the motor is in full field. If further reduction of speed then occurs, the generated volts are no longer higher than the line voltage. The equipment is designed to give rheostatic braking at speeds below the effective range of regenerative braking down to about four miles per hour. Below four miles per hour the electric braking falls away, and the vehicle is finally brought to rest by the foot brake. The master controller is operated by a foot pedal and its operation is very simple. Forward depression of the pedal applies power, and electric braking is effected by releasing the pedal slowly. To prevent excessive voltage being generated when applying the regeneration feature, an overvoltage relay is provided. In the event of the trolley coming off the line, or the line voltage failing at a time when the vehicle is regenerating, the overvoltage relay operates a contactor which closes the motor circuit through a resistance, thereby providing automatically a rheostatic electric brake.

All of the electrical equipment is mounted under the rear cross-seat. The contactor panel and resistances are located behind hinged doors in the back panel. The equipment is mounted on a frame and can be withdrawn as a unit.

One former deficiency of the trolleybus, which also applies to the street car, was due to the fact that current was collected from a trolley wire. Any serious obstruction along the route, such as an accident, a fire, etc., meant that the service was interrupted. The new trolleybus has batteries of sufficient capacity to drive the motor so that the bus may be operated on side streets at slow speed for a maximum distance of one mile on level ground, thereby assuring continuity of service. This feature will also be of assistance for short movements of the vehicle in yards or garages.

Many variations in design and operating characteristics appear in the trolleybuses of to-day. Those of American makes are entirely of metal, with the exception of the flooring. Most of them utilize steel, though some employ a combination of steel and aluminum. The body and chassis are built in one unit, following in that the practice for gasoline buses of the Metropolitan type. Some trolleybuses are equipped with a single motor, others have two motors. The tendency favours the use of one motor of large capacity, with the advantage of lower first cost, lower overall weight, and less apparatus to be maintained. Motors of 125 hp. have been developed for this purpose. Regenerative braking has not yet been adopted by the United States manufacturers, and the deceleration and stopping of the vehicle has to be performed by the air brake, which in the case of an electric vehicle is hard on the brake shoes. The control is fully automatic and sufficient accelerating steps are provided to accelerate the bus smoothly and confortably giving a maximum acceleration of 4 miles per hour per second. Overall lengths vary in proportion to the seating capacity, and are not very different from those of the gasoline buses of the Metropolitan type. The largest single deck trolleybuses in service to-day are the 42-passenger vehicles built for Youngstown and Milwaukee. Their overall length is 36 ft., and the width for the Youngstown units is 106 in. Generally the overall width is 8 ft.

POWER

When the operation of electric cars started in 1892, power for this purpose was generated only by large, slow

Fig. 16—William Street Power House, Montreal. 1894.

speed steam engines, to which were connected or belted direct current generators. The advent of the power generated by turbo-generators and especially by hydro-electric plants superseded those early steam plants, and led up to the automatic converting substations of to-day.

The history of the production of power for the use of street cars can best be outlined by giving that of the two largest cities in Canada; Montreal and Toronto. Development in other cities has been along similar lines.

City of Montreal

In Montreal, the power supply for the first operation of electric cars in 1892 was delivered from two 200 kw. 400 r.p.m. 600 volt Edison bi-polar generators belt driven by two Robb-Armstrong engines. This plant was located in the south-east corner of the Côté street car barn. In addition to the above plant, two similar 200 kw. units at the Royal Electric Company's, Queen street plant, were belt-driven by a vertical cross-compound engine, the generators being operated in parallel with those at Côté street.

Both these plants were abandoned when displaced by the William street station which was put into commission in 1894. The above mentioned four 200 kw. Edison units were transferred to William street station, along with eight additional Edison 200 kw. 600 volt generators driven by three 650 hp. engines (4 on each 650 hp. engine). There were added six 300 kw. 400 r.p.m. multi-polar Thomson-Houston type 600 volt generators belted to three (2 on each) 650 hp. cross compound horizontal engines. Thus in December 1894, the capacity of William street station was 4,200 kw.

From 1894 to 1901, the William street plant capacity was further increased by the addition of one 1,500 kw. multipolar generator, 75 r.p.m., direct connected to a 3,000 hp. horizontal cross compound condensing engine, and of two 850 kw. multipolar, 85 r.p.m. 600-volt generators, direct connected to two 1,500 hp. engines. This installation was accompanied by the necessary boiler plant, stack, economizers, piping and condensing equipment. On account of their slow speed the above units were of very large size.

This made the total capacity of William street steam plant 7,400 kw. at the end of 1901. This plant was in operation up to about the year 1917, when it was replaced by the new Hochelaga high tension steam turbo generator plant.

The original installation at the Hochelaga plant consisted of one 17,000 hp. 1,800 r.p.m. turbine, direct connected to a 15,600-kva. 3-phase, 60-cycle, 13,000-volt generator. A similar unit was added during 1923, which brought the total capacity of the plant to 25,000 kw. The a.c. power generated was distributed to the several substations at 13,000 volts through the Montreal Tramways Company's underground conduit system.

The purchase of alternating current from hydro-electric plants began in 1901. Its use steadily grew until in 1925 it totally displaced power produced by steam. The Hochelaga plant has since been used only as standby.

In March 1901, the first hydro-electric power was first used at William street station, one Westinghouse 375-kw. 600-volt generator being belted to two Stanley 2,200-volt, 2-phase, 60-cycle synchronous motors coupled in parallel.

During the same year, seven additional 500-kw. direct connected motor generator sets were installed, also using two-phase 2,200-volt, 60-cycle current.

The above equipment was in constant operation until 1930, when the plant was abandoned and the machinery discarded.

Until 1904, all the production and conversion of the power required for the operation of the tramways in Montreal was centred at one point; William street

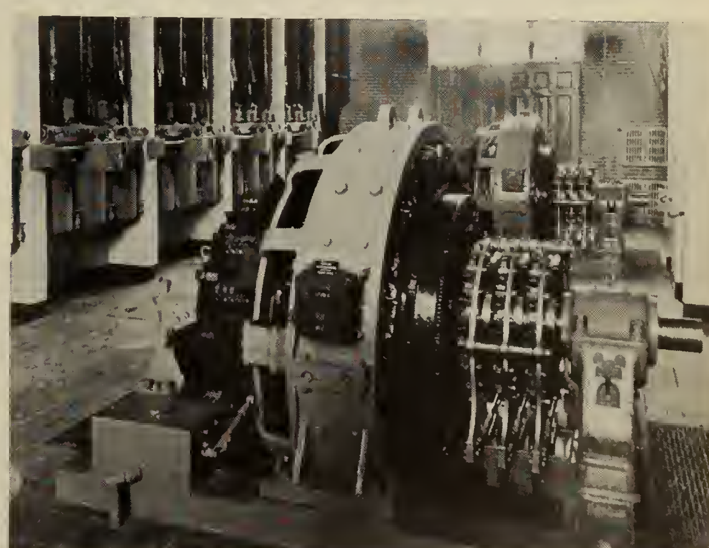

Fig. 17—Guy Street Substation, Montreal. 1929.
Two 2,000 kw. Rotary Converters.

Fig. 18—Queen Mary Road Substation, Montreal. 1930.

station. As the city grew it became uneconomical to distribute current at 600 volts to such great distances, so that converting substations properly distributed over the system became necessary.

During the years 1904-1905, both St. Henry and St. Denis substations were erected. They were equipped originally with induction motor-generator sets of 500 kw. capacity each.

Some of these machines are still in service. The year 1913 marked the arrival of machines of greater capacity One 1,500-kw. 2,300-volt, 3-phase, 60-cycle synchronous motor-generator set, 600-volt, compound wound, was installed at William street substation. Installations of similar machines were made at St. Henry and St. Denis substations during the following years.

It may be of interest to note that in 1906, in order to increase the capacity during the hours of peak loads, 280-cell Exide storage batteries were installed in each of the above two substations—St. Denis and St. Henry, also in the Shawinigan substation. Each of these batteries had a maximum discharge rate of 1,400 amperes for twenty minutes at 600 volts; they were operated in parallel with the motor-generator plant. One renewal of the positive plates was made during the year 1912. These battery plants were abandoned and scrapped in 1916.

The first rotary converters used in Montreal were installed by the Shawinigan Water and Power Company, at their substation on Orleans street, during 1905 and 1906, and consisted of three 1,000-hp. units. They delivered d.c. power to the Montreal Tramways Company, for its street car service. The above machines were in continuous service until the year 1930, at which time the contract terminated.

The first substation of the Montreal Tramways Company, in which rotary converters of large capacity were installed, was located on Côté street, and was built during the years 1920-1921. Four units, each 2,000-kw. 3-phase, 60-cycle, 600-volt d.c. Canadian General Electric Company, rotary converters were installed.

This was followed by the erection of Mount-Royal substation in the years 1924-1925, where three similar units were installed.

The year 1927 marked the appearance of metallic tank mercury arc rectifiers for street railway service. During that year Verdun substation was built and equipped with three Brown Boveri, double tank, 600-volt, 1,200-kw. mercury arc rectifiers. This was also the first station to be made fully automatic.

This was followed by the erection of several other fully automatic mercury arc rectifier substations, but using single tank rectifiers, as follows:—

| | |
|---|---|
| Year 1928—Rockfield Substation...... | 2—Brown Boveri 1,200-kw. rectifiers. |
| Year 1929—Viau Substation.......... | 2—12 Anode, General Electric 1,500-kw. rectifiers. |
| Year 1930—Queen Mary Substation... | 2—1,500-kw.—12 anode, General Electric rectifiers. |
| Year 1936—Ahuntsic Substation...... | 1—Brown Boveri 1,200-kw. type B-612-C rectifier. |

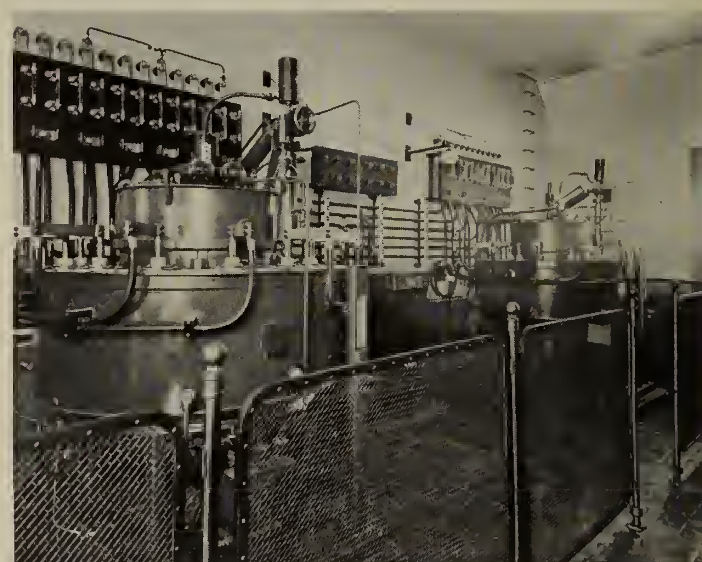

Fig. 19—Queen Mary Road Substation, Montreal. Two 1,500-kw. Mercury Arc Rectifiers. Operation Fully Automatic and Supervisory Controlled.

During 1929, a fully automatic substation was also built on Guy street, equipped with two 2,000-kw., 12-pole Canadian Westinghouse, compound 600-volt d.c. synchronous rotary converters.

Three of these substations, Guy, Queen Mary, and Viau, are supervisory-controlled from the Côté street central station.

To illustrate the functions of these substations (which do not require any attendant), the main features of the fully automatic rectifier substation located on Queen Mary road, may be noted as follows: This station can function on load responsive impulse; by supervisory control from load dispatcher's office, or manually from the switch-board in the substation. When operating automatically, the starting indication is given when the direct current trolley current falls below a predetermined value, provided that the high tension supply has the proper phase and voltage conditions. The second unit is started when the load on the first has reached a predetermined value for a certain definite time. Should the first unit fail to start the second unit is set in operation and entirely replaces the first unit. The second unit shuts down when the load on the station decreases sufficiently to be carried by one unit only, and the first rectifier is shut down when the load has fallen below a suitable value, provided the d.c. bus voltage is above a certain amount.

The above description will be sufficient to show the trend of development in the conversion of alternating to direct current used on this important street railway system.

Another interesting development is the present practice of building substations of smaller capacity, thereby restricting the feeding area of the station. These are located at the centre of gravity of the load, so that less feeders are required and the difficulties with the return current are also lessened.

The amount of capital invested in substations and distribution lines necessary for the operation of a tramway system is quite large. The value of receiving and converting substations, high tension transmission lines, d.c. feeders and returns, and trolley lines, including all equipment from the point of delivery of hydro-power to the trolley wheel of the car, runs from 15 to 20 per cent of the value of the entire tramway system.

Since 1925, all the power used by the Montreal Tramways Company, has been furnished and delivered by Montreal Light, Heat and Power Cons., at two main points: Hochelaga and St. Henry. From these points it is distributed to the several substations at 13,200 volts. The Montreal Tramways Company owns and maintains 16.3 miles of underground conduits, used exclusively for its 50.6 miles of high tension underground substation tie-cables, together with its 12.5 miles of underground control cables, radiating from the load dispatching office at Côté street, to the various automatic substations. The aerial substation high tension distribution is 8.8 miles long. There are 106 miles of 600-volt feeder and return cables installed in the municipal conduit system. The aerial 600-volt d.c. feeders and returns have a total of 250 miles of cable distribution.

There are at present fourteen converting substations spread all over the system with a total rated capacity of 49,000 kw.

The maximum daily peak load on the system during the winter months at 6.00 p.m., is generally around 45,000 kw., and a maximum of 49,225 kw. was reached in February 1935. In Fig. 20, a graph is shown of the daily load curve of the Montreal Tramways Company, during a typical winter month. It is interesting to note the great increase in power demand during rush hours, morning and evening. It amounts to some two to two and a half times the power requirement during other hours of the day.

### City of Toronto

The following historical notes have been kindly furnished by the Toronto Transportation Commission.

The Toronto Railway Company, in the year 1892, established a steam plant of their own at Frederick and Front streets. It consisted of four 450-hp. Armington and Sims condensing high speed steam engines, belted to two Edison 200-kw. 550-volt generators, and one 350-hp. engine belted to one 200-kw. and one 125-kw. Edison generator.

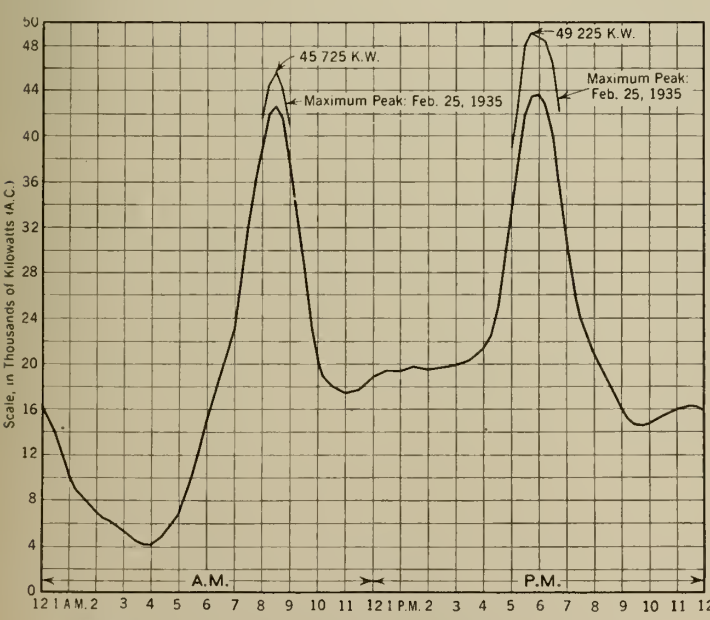


**Fig. 20—Typical Load Curve in Winter. Montreal Tramways Company.**

The plant was steadily increased and by 1905 had reached a capacity of 6,000 kw. The equipment consisted of six 26 by 52 by 48 Corliss compound engines direct connected to six 850-kw. 85-r.p.m. generators.

Niagara power arrived in November 1906, and the load was gradually transferred to Canadian General Electric 12-pole - 1,000-kw. - 250-r.p.m. - 25-cycle - 6-phase rotary converters (575 volts d.c.). All steam plant equipment has been scrapped subsequently.

The converting equipment was built up to sixteen rotary converters, all of which are in operation at present.

In 1921, when the Toronto Transportation Commission took over and consolidated all the street railway lines around Toronto, it became necessary to arrange for additional power. This was obtained by purchasing direct current power from the Toronto Hydro-Electric System, who own and operate for that purpose seven converting substations.

Six stations are equipped with rotary converters, of which two are fully automatic. The capacity of these stations varies from 2,000-kw. to 4,000-kw.; rotary converters are 1,000-kw. each.

In 1929, the Ossington substation was built. It is equipped with two 1,100-kw. Brown Boveri rectifiers, and its operation is fully automatic.

The total capacity for the system, as of December 1st, 1936, was 36,700 kw.

### PERMANENT WAY

Previous to 1892, when horse cars were operated, track construction was quite primitive. The rail was a rolled section consisting of an iron strap 4½ in. wide, ⅜ in. deep on the flat part, with a lug on one side 1¼ in. deep, and weighed about 30 lb. to the yard. It was fastened to longitudinal stringers, generally 4 in. by 6 in. or 6 in. by 8 in., by countersunk spikes at intervals of 18 in. The stringers rested on wooden ties spaced about six feet apart. No special foundation was provided, the ties being set only on a bed of gravel ballast. The paving surface consisted of macadam or cedar pole blocks, six inches deep, the space between the blocks was filled with sand.

### Trackwork

When the horse car systems were electrified this track design proved to be totally inadequate and unsuitable for the return of the electric current. A different type was needed.

The new trackwork for electric railway systems used grooved rails, 6½ in. deep and weighing from 70 lb. to 73 lb. to the yard. They were laid on wooden pole ties, 6 in. by 8 in. by 7 ft. long, spaced on 2-ft. centres. No special foundation was provided at that time, and the ties often rested on natural ground. In other instances, however, the subgrade was covered by a layer of 3 to 4 in. of gravel or of excavated macadam material. The pavement consisted of macadam, wooden blocks or stone blocks. A concrete paving base was first laid filling the space between the ties and covering them by an inch or so. The blocks were then laid on a layer of sand, one inch thick. The above structure was not quite satisfactory, except when it was built on exceptionally good soil, as it lacked proper foundation. It gave rise to a good deal of movement of the rail, causing a rapid deterioration of the pavement.

About 1900, another type was developed. The base was made of concrete in the shape of a concrete floor with stringers and slab. The stringers built longitudinally under each rail measured from 20 to 24 in. wide, and 8 to 12 in. deep below the base of the rail; the slab, between and on each side of the stringers, was from 6 to 8 in. thick and served as paving base. The whole was concreted in one operation from the subgrade to the top of the slab, the base of the rail being thus embedded in the concrete. Wooden ties or steel ties were used, though in some instances the ties were totally dispensed with. The pavement consisting of blocks was laid in the usual way. The above type of track structure also developed certain weaknesses, and was discontinued about 1910.

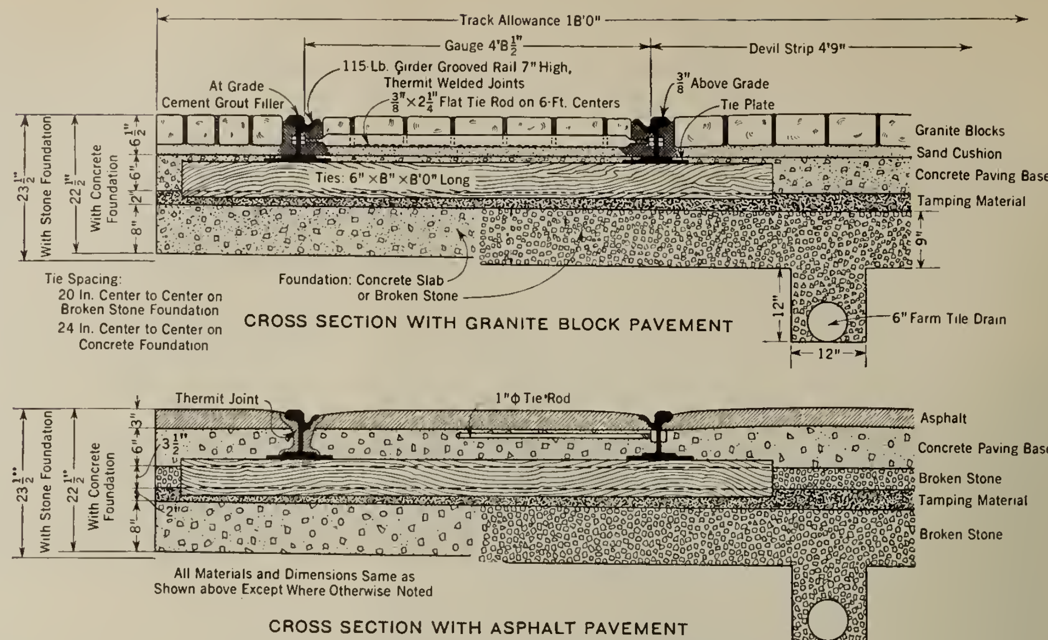


**Fig. 21—Standard Track Construction, Montreal. 1932.**

An important change was made about 1906, when it was decided that the "devil strip" must be widened in order to allow the use of wider cars. In Toronto, the width of the devil strip was increased from 3 ft. 10 in. to 5 ft. 4 in., and in Montreal, from 4 ft. to 4 ft. 9 in. These are standard to-day.

About 1910, in order to properly distribute the load on the soil, the practice of building a suitable separate foundation was commenced. It developed along two lines, one in which the ties rested on a continuous layer of broken stone, and the other in which a concrete mat was constructed on the whole width of the track structure. These types of foundation have given good results; they are still standard to-day. The thickness of the stone foundation is ordinarily 9 in. and the concrete mat, 8 to 9 in. The above mentioned track structure requires an excavation 22 to 24 in. below the level of the surface of the roadway. Beneath the level of the subgrade in the centre of the devil strip, a sub-trench 12 in. by 12 in. is excavated, and drainage is provided by inserting in this trench a 6 in. tile drain embedded in crushed stone, and connected to the sewers at convenient points.

*Ties*

Wooden pole ties have remained the accepted practice in Canada, since the advent of the system, although, steel ties embedded in a concrete base were used in a few instances. The use of treated ties has not been greatly favoured in Canada when laid on streets with permanent pavement, where the ties are sealed by the concrete paving base. However, in open track, their use is general. Ties, 6 in. by 8 in. by 8 ft. long, are laid on a layer of tamping material and are spaced generally at 20 in. centres in the case of crushed stone foundation, and 24 in. in the case of concrete foundation.

A new design of track structure for street railways has been developed during the last few years, in which the rails are laid on light steel cross-ties spaced on 4-ft. to 6-ft. centres, and the whole is concreted from the subgrade to the surface in one operation, forming a monolithic rigid structure. The concrete would be some 3 in. below the surface. The concrete slab is reinforced near the bottom with steel fabric, and additional anchorage for the rail is provided by round bars, spaced about two feet, which are inserted through holes in the web of the rail.

This type of construction has some good points, but has only been used in a few cities, and is still in the experimental stage. It has not been used in Canada.

*Rails*

The weight of grooved rails since 1892 has steadily increased from 72 lb. to the yard, to 83, 88, 96, 115 and 122 lb. to the yard. A certain amount of 87 lb. and 90 lb. high tee rail was also used, but since about 1916, its use has been practically discontinued on streets where permanent pavement is laid, grooved girder rail being substituted. It is of interest to note that in Montreal, since 1918, the use of tee rail on paved streets is not permitted. In the early days, the rails were laid directly on the wooden ties, but with heavier rolling equipment, it became necessary to place bearing tie plates between the rail and the tie.

Not only has the weight of the rail been increased, but the composition of the steel has been changed somewhat. The carbon content has been increased gradually from approximately 0.4 per cent to 0.7 per cent, while the manganese content has been slightly decreased. Some years ago, some intermediate manganese rail with a content bearing approximately 1.5 per cent of manganese was installed in Montreal, as an experiment. Results obtained up until now promise increased life, though the harder rail has shown a tendency to brittleness by an increase in the number of fractures. Rail treated by the Sandberg sorbitic surface hardening process has been laid at test locations, but results are not yet conclusive.

*Joints*

Since the inauguration of the electric system the tracks have been utilized as a conductor for the return current. As bolted joints were standard practice in the earlier days, the rails were connected at each joint with copper bonds soldered to the rails. With the introduction of the seam-welded joint, about twenty-five years ago, copper bonds were abandoned and the connecting side plates were welded to the rail, the parallel rails being connected together however, with cross bonding every 400 feet.

One of the most important developments in track construction has been the adoption of the thermit welding process for rail joints, which has been standard practice since 1931. In this process, the ends of the rails are welded together, forming a continuous head section. The result is a continuous surface on which the car can run smoothly, thus greatly lessening the noise of the car. The cost of track maintenance is also materially decreased. The question may be asked, what is the result of the expansion and contraction of the steel? It must be noted that the rail is embedded in the pavement, and rigidly fixed to the track structure. Actually the rail is so well held in position, that the tendency toward expansion and contraction results only in increase or decrease in internal tension in the steel. It may be of interest to add, that rail welded by the thermit process has been used even in open trackwork, in several instances. In Montreal, in the Wellington tunnel under the Lachine canal, for a length of 1,473 feet (including the two ramps), the rail joints are thermit welded, and no break has yet occurred. Another piece of open trackwork, 900 feet long, on Cote des Neiges private right-of-way, was similarly constructed recently.

### Special Trackwork Layouts at Intersections

These special trackwork layouts are very costly, and deserve special attention. The cost of the steel alone for a grand union intersection layout, viz: with eight curves, is in the neighbourhood of thirty thousand dollars. The cost of the complete structure, including the pavement, amounts to some forty-five thousand dollars.

Curves for intersection layouts were originally designed with one radius throughout, and switches were made with a 45 ft. radius. About 1900, the radius of switches was increased to approximately 100 feet, and easement curves were installed between the heel of the switch and the main central arc. Some twenty-five years ago, clearance curves with long easement ends were introduced, and a 200 ft. radius switch was manufactured to permit clearance of cars in any position. This was of great value in the operation of cars at busy intersections.

The designs of the switch, mate and frog pieces have been constantly improved and standardized to secure interchangeability and ease of replacement from material in stock. In fact the Canadian companies, in respect of the standardization of special layouts, are far in advance of American companies, who are presently working toward the same goal.

Switches, mates and frogs were originally manufactured of cast steel. About 1895, the tongues and part of the head were made of manganese steel, and by 1900, the entire switch, as well as mates and crosses, was being constructed of this metal. Experimental installations were also made with alloy steel of nickel, chrome nickel and high silicon content. To-day the general practice is to use manganese steel with a manganese content of 12 to 14 per cent.

On account of the high cost of special steel layouts, it is important that their life be prolonged. Welding has been of great value in this regard. It was first thought that manganese steel could not be welded with good results, but about 1920, experiments were made with success. This led to further improvement, and today, the practice of welding manganese steel has extended the life of these expensive pieces by almost 75 per cent.

### Pavement

The type of paving most used to-day is of granite blocks and asphalt; in both cases a concrete paving base is built. The blocks are laid on a cushion of sand or of a dry mixture of sand and cement; concrete surfacing has not been used to a great extent in Canada.

What is also worth noting, is that the maintenance of the surfacing of the roadway in the track area, which is to-day solely used by vehicles other than street cars, is in most cities done at the expense of the tramway companies. This is a relic of the time of the horse cars, and though fifty years have since elapsed, and conditions with respect to the use of the pavement have totally changed, this practice has not changed. The enormous increase in traffic, and the use of chains in winter by automobiles and heavily loaded trucks, have rendered the upkeep of the pavement very onerous. The street car passenger through his fare has to pay for that, and fifty years of progress has not helped him at all in this respect; on the contrary the situation has grown worse.

### Cost of Trackwork

The high cost of intersection layouts has already been noted. It may be of interest to mention that the cost of a double track street car line, with paving, poles and trolley wires, built under average conditions, is not less than one hundred and fifteen thousand dollars per mile of street.

The total cost of trackwork of a street railway runs from 25 to 30 per cent value of the entire system

### Economics of Transportation

With the advent of new types of vehicles, the economics of mass transportation have necessarily been modified.

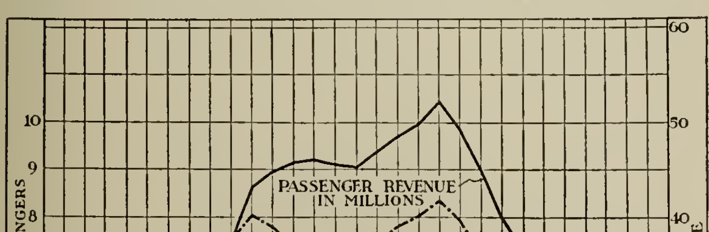


Fig. 22—Passenger Revenue. Canadian Electric Railways.

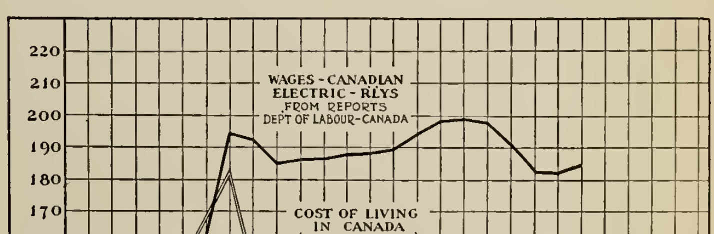


Fig. 23—Fares and Wages. Canadian Electric Railways.

Up to about 1920, street railways were the only practical type of urban transportation on surface streets, large, medium, or small cities had to use the same system. To serve suburban localities, long mileage of trackwork with electric lines had to be installed, which were used only to a limited extent. Maintenance, interest and overhead charges were abnormally high in these cases, due to the small amount of traffic to be handled.

At the present time, three different kinds of service are available on surface streets, depending on the density of traffic: that of the street car, the trolleybus and the autobus. Each of these types has a definite place in a modern system of transportation.

Transportation by subway is not included, as no city in Canada has a sufficient population at the present time, to justify subway construction. In order to have a return sufficient to meet the expenditure, the fare would have to be so high that it would not be practicable. An elevated railway in the heart of a city, though less expensive than a subway, is no longer favoured, as it kills the development of the street along which it is built. Cities where they exist are either tearing them down or propose to do so.

In our large cities the street railway is still the backbone of mass transportation. Due to the large carrying capacity of street cars, and due to the fact that they operate on a track, they can move more passengers for a fixed area of street occupancy than any other type of surface vehicle that can be operated in this country. In the heart of the larger cities having a population near or exceeding the million mark, the interval between cars at certain points is as low as twenty to thirty seconds. To this stream of street cars must be added the steady flow of automobiles. As most of the streets in the heart of our cities only allow for four lanes of traffic, two in each direction, it is easily understood that the street space must be economized to the limit. It has been said that the roadways built over half a century ago, are not an inch wider to-day, and modern traffic leaves them sadly unable to carry their load. As the late Mr. Seurot, of the Montreal Tramways Company, used to say, "we are now facing the arteriosclerosis of circulation." The solution of the problem is certainly not to substitute for the street car on main arteries of traffic, any type of vehicle which will occupy more space per passenger, as is sometimes suggested.

It is important to note that for all cities of a population over 500,000 on the American continent, during 1936, for mass transportation on surface streets, 77.74 per cent of the passengers were transported by street cars, 1.19 per cent by trolleybus, and 21.07 per cent by autobus. This proves conclusively, that for cities of that size, electric railways are still the backbone of mass transportation. They are also the most economical means, when headways are sufficiently short to distribute the cost of the trackwork over a large number of car-miles. There are, however, certain routes on which the movement of passengers is sufficiently heavy to bear the cost of poles and trolley lines, but which cannot economically support the cost of the trackwork. These are better served by the trolleybus, which under these conditions will be the most economical of all. The trolleybus is certainly the finest type of vehicle there is, and for medium traffic on streets where there is no objection to the erection of poles and trolley wires, it offers the best mode of city transportation.

Then comes the third division, viz. routes on which the number of vehicles in service is not large enough to justify economically the erection of trolley lines, and streets where there are objections to doing so. This is the place for autobuses. They offer the special advantage in newly developed districts of not requiring any capital investments other than the purchase of the vehicles.

The development of these new vehicles has brought a great change in transportation systems in the last fifteen years. In large cities, the electric railway companies early realized that autobuses could be used with success as feeder lines to their main tramway system, or on routes where the construction of tracks was not necessary. Many street car lines were changed to bus routes when the tracks had to be rebuilt. To-day the necessity of any proposed renewal of trackwork must be carefully examined.

A great number of cities have totally abandoned their street car services and substituted motorbuses. It may be stated that for all cities of a population not exceeding 150,000 the construction of an electric railway system cannot be justified. Those still in existence will not be

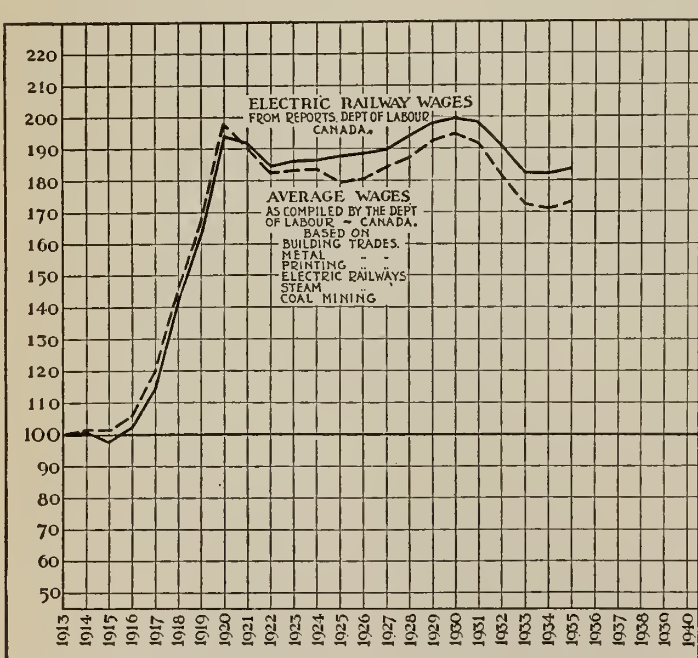


**Fig. 24—Canadian Electric Railways Wages Compared with Average Wages of Railways and other Trades in Canada.**

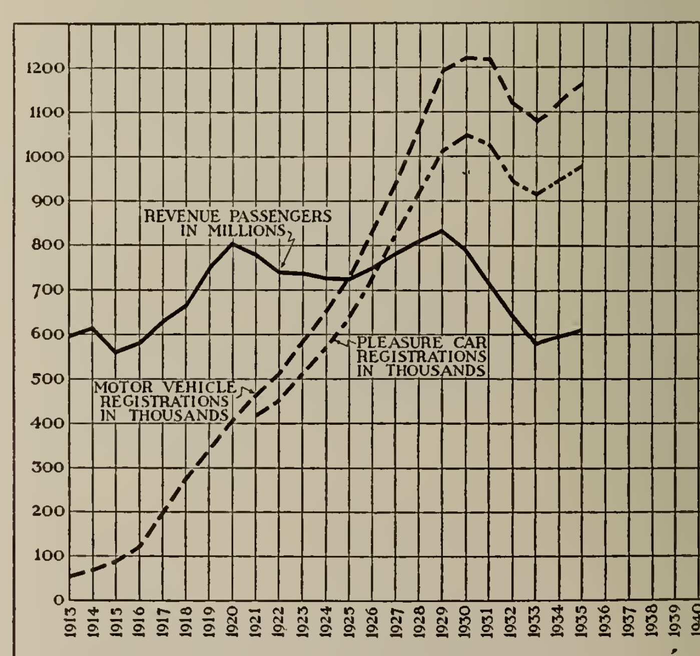


**Fig. 25—Revenue Passengers. Canadian Electric Railways.**

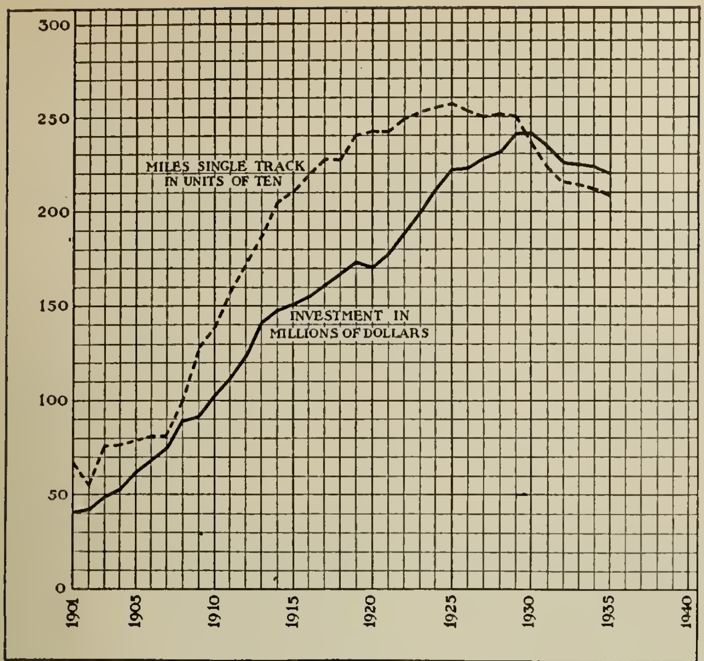


**Fig. 26—Investment in Canadian Electric Railways.**

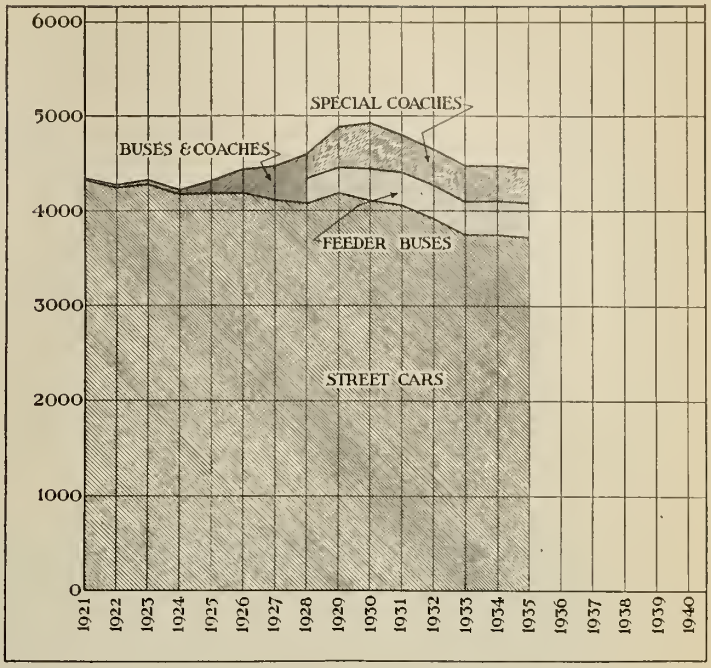


**Fig. 27—Street Cars, Buses and Coaches in use by Electric Railways in Canada.**

renewed when the expenditure for maintenance and replacement becomes too onerous.

During the year 1936, mass transportation traffic in cities of 100,000 population and under on the American continent, was divided as follows: tramways 48.2 per cent, trolleybus 1.8 per cent, and motorbuses 50 per cent.

### Statistics

Through the courtesy of the Canadian Transit Association, a number of important electric railway statistics are reproduced in graphic form in this paper. Being all in the form of charts, they speak for themselves, and no comment need be added.

### GENERAL CONSIDERATIONS ON STREET TRAFFIC

It is not necessary to describe the traffic conditions existing to-day in the main arteries of our large cities. In the central districts, the streets are choked with vehicles, and an average speed of five miles per hour is not uncommon in certain congested sections.

Under such conditions, are we at least making the best use of what we have? On the contrary, we have permitted a practice to be introduced, the parking of automobiles, which often reduces by one half the capacity of streets already too narrow

From an economic point of view, this is a fundamental error; the value of the space occupied in main arteries by parked vehicles is out of all proportion to the service rendered. A city possesses no more valuable property than its streets. The result is that cities are called upon to build ahead of time subways to provide the service that could be given on surface streets.

Every year more citizens use the private automobile to travel from their homes to their places of business or vice versa, so that during rush hours, the main arteries of circulation are flooded with private cars. There is a definite limit to the number of vehicles which can move through streets at reasonable speed. Large cities were not built, and cannot be transformed economically, to permit the transportation of their citizens on a large scale by individual automobiles.

To remove the trouble by providing additional streets or widening existing ones, with provision for grade separation at many points, would require a tremendous capital expenditure. The building of subways, thereby releasing the streets for the balance of the traffic, would also be very costly. The method to be adopted should be one which will give the best results for the amount of capital invested, due consideration being given to the interests of the citizens at large.

For instance, in several cities, huge expenditures have been made to provide street facilities which are used almost exclusively by private automobiles. This may have been justified to a certain extent in exceptional cases, but it is doubtful if in a great number of them this was sound economically. It has even happened that the opening of the new arteries only invited more cars to travel, with the result that soon afterwards, the general traffic conditions were no better than before.

The question may be raised as to whether it would not have been preferable in many cases to spend that money on subways. It must not be forgotten that 75 to 80 per cent of the population of large cities has to be carried by mass transportation agencies; special counts made in different cities have substantiated this statement beyond a doubt. Eighty per cent of the population would have benefited from the construction of the subway, against the 10 or 15 per cent who use automobiles for individual transportation. Besides as already mentioned existing streets would have been relieved for automobile use. The objective should be to co-ordinate the construction and operation of these new facilities in such a way as to provide a maximum of public benefit.

All cities to-day, medium or large, should give special attention to their traffic problem, first to improve their existing facilities, and secondly to provide, within reason, for the probable conditions of the future. It is certain that Canada is going to expand extensively during the next fifty years. In the future as in the past, the question of urban transportation will be of vital importance for the proper development and functioning of our centres of population.

* * * *

Note:—The author desires to thank the officers of the several tramway companies operating in Canada, who have kindly furnished him with data required for the preparation of this work. Information was also taken from several journals and books dealing with urban transportation during the last fifty years.

# Waterways Development

*The Hon. C. D. Howe, Hon. M.E.I.C.,*
*Minister of Transport, Ottawa, Ontario*

The development of waterways along the St. Lawrence river and through the Great Lakes has been so extensive that they dwarf all other inland waterways, not only in Canada but in the entire world.

Some idea of the extent of the traffic carried may be obtained by comparison with the traffic carried by the great inter-ocean canals of the world, the Suez and the Panama.

For this purpose, as the St. Lawrence-Great Lakes waterways are international in their character, the tonnage through the Sault Ste. Marie canals, both Canada and United States is given below as an index:—

Table I

| Year | Sault Ste. Marie Canals | | Suez Canal | | Panama Canal | |
|---|---|---|---|---|---|---|
| | Vessels number | Freight tons (2,000 lb.) | Vessels number | Freight tons (2,000 lb.) | Vessels number | Freight tons (2,000 lb.) |
| 1928 | 19,286 | 86,994,254 | 6,084 | 35,959,231 | 6,253 | 33,169,529 |
| 1929 | 19,794 | 92,618,898 | 6,274 | 38,046,868 | 6,289 | 33,525,500 |
| 1930 | 16,820 | 72,897,895 | 5,761 | 31,427,675 | 6,027 | 33,620,640 |
| 1931 | 13,056 | 44,606,325 | 5,366 | 27,924,000 | 5,370 | 28,073,117 |
| 1932 | 8,679 | 20,484,169 | 5,032 | 26,050,000 | 4,362 | 22,174,864 |
| 1933 | 12,100 | 40,303,398 | 5,423 | 29,669,000 | 4,162 | 20,340,505 |
| 1934 | 11,395 | 42,247,556 | 5,663 | 31,359,000 | 5,234 | 27,668,490 |
| 1935 | 12,959 | 48,292,973 | 5,992 | 29,074,000 | 5,180 | 28,346,670 |
| 1936 | 16,614 | 69,528,795 | 5,877 | 28,221,500 | 5,382 | 29,686,152 |

The season of navigation on the Great Lakes is about seven months or two hundred and forty-three days per year. Nevertheless during the years 1928 and 1929, the Sault Ste. Marie canal carried about three times as much freight as either the Suez canal or the Panama canal. The depression hit this lake traffic more severely than the ocean traffic, but the above table shows it is rapidly recovering its pre-eminence over the great inter-ocean canals.

St. Lawrence River and Great Lakes

The St. Lawrence river is the natural route from the Atlantic to the Great Lakes, and with the lakes provides a course of water communication extending 2,218 statute miles through Canada, from the Strait of Belle Isle to Port Arthur and Fort William on the west coast of Lake Superior, about 600 ft. above sea level.

The St. Lawrence river is naturally divided into two sections, the lower extending from the Gulf of St. Lawrence to Montreal, and the upper, from Montreal to Lake Ontario.

The lower section was, until the organization of the Department of Transport, more or less controlled by the Department of Marine and was officially known as the "St. Lawrence Ship Channel."

A considerable amount of dredging work was done prior to 1887 (from 1850 the channel under the control of the Montreal Harbour Commissioners was deepened from stage to stage), and in 1888 there was 25 ft. draft available which had been obtained at a cost of three million dollars.

In 1889 the control and management of the channel was transferred to the Department of Public Works, and work was started on a 27-ft. channel which was completed in 1898 but in 1899 it was decided that the channel should be 30 ft. The Department of Marine took over this work in 1904 but before the 30-ft. channel was completed, owing to the rapidly increasing size of vessels, it was decided in 1910 to increase the depth of the channel to 35 ft. at low water. It is expected that this 35-ft. channel will be completed during the current year.

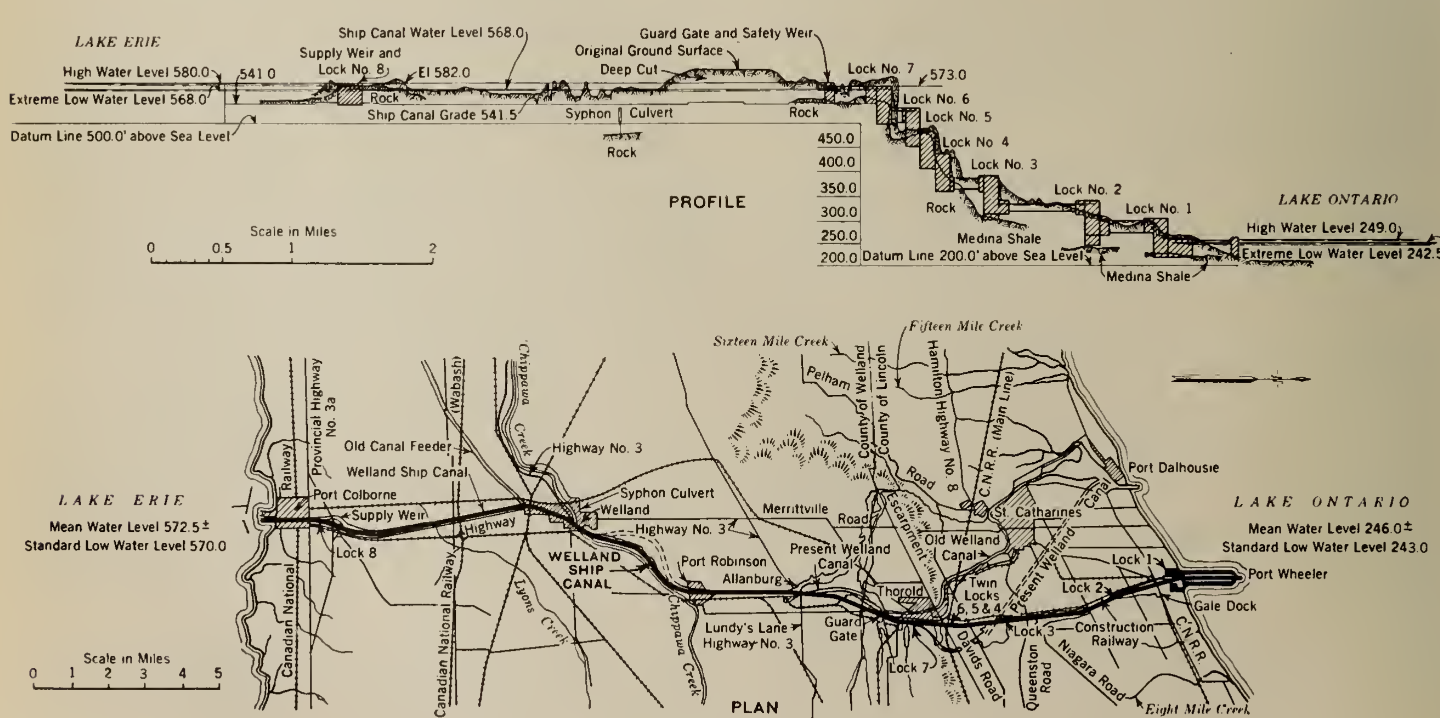


Fig. 1—Plan and Profile of Welland Ship Canal.

Welland Ship Canal at Syphon Culvert

The Canal crosses Chippawa Creek at this point, which necessitated the construction of an inverted syphon culvert to carry the river water under the Canal. The foundations of this structure stand at a depth of 86 feet below the level of the water of the Canal, and six tubes, each 22 feet in diameter, form the water passage by which Chippawa Creek flows on to the Niagara River.

Fig. 2—Flight Locks, Welland Ship Canal.

Ice breakers have been employed for thirty years on the St. Lawrence river, primarily to prevent floods, but a secondary result has been to lengthen the season of navigation.

The average date of the first arrival at Montreal during the past five years has been April 26th, and the average date of the last departure, November 26th, which is an average increase of nineteen days in the season of navigation compared with the previous years.

The upper section, because of its necessary canals, has been almost entirely within the jurisdiction of the Department of Railways and Canals, with the Department of Marine furnishing aids to navigation in the way of buoys and lights and the Department of Public Works doing the dredging in uncanalized stretches.

Fifty years ago, between Montreal and Lake Ontario, the St. Lawrence river, with the aid of a number of canals, provided a draft of 9 ft., and the provision for 14-ft. draft was under way, but this undertaking was not completed until 1904.

A short outline of these various canals, with the important improvements during the period 1887-1937, is as follows:—

The Lachine canal was built to overcome the Lachine rapids, and extended from Montreal harbour to Lake St. Louis, 8.74 miles long with 14 ft. depth in the locks, but only 12 ft. in the canal. The work of enlarging the canal to 14 ft. depth was completed in 1899.

The Beauharnois canal, which provided navigation past the Cedar Rapids, extended from Lake St. Louis to Lake St. Francis, 11¼ miles long, 9 ft. depth. It was replaced in 1899 by the Soulanges canal, 14.67 miles long and 14 ft. depth.

The Cornwall canal was built to overcome the Long Sault rapids, and extended from the town of Cornwall to the village of Dickenson's Landing 11.00 miles long, 9 ft. depth. It was enlarged to give a 14-ft. depth, completed in 1904.

Farren's Point canal, 1.28 miles long, 9 ft. depth, built to pass Farren's Point rapids, was enlarged to provide for a 14 ft. depth, completed in 1901, and the upper entrance was extended 1,700 ft. up stream.

The Rapide Plat canal, 3.89 miles long, 9 ft. depth, built to pass the Rapide Plat rapids, was enlarged to 14 ft. depth, completed in 1904.

The Galops canal was built to pass the rapids at Iroquois Point, Cardinal Point, and the Galops. This canal, 7.36 miles long, 9 ft. depth, was enlarged to provide a 14-ft. depth completed in 1904, and, in 1907-1908, the north channel was dug to provide a better entrance to the canal at the upper end, and Gut dam between Galops and Adams island was built to improve conditions at the upper entrance.

Between Prescott and the junction of the St. Lawrence river and Lake Ontario at Kingston, a distance of 66 miles, improvements in the alignment of the ship channel have been made between 1887 and 1937, and a considerable quantity of solid rock has had to be excavated to make these improvements. The Canadian channel in this stretch now provides a navigable depth of 27 ft. below Lake Ontario elevation 244.5.

The canals on the St. Lawrence river, as at present constructed, control the size of vessel that can traverse the through route and the limiting lock in this respect is situated at Cornwall on the Cornwall canal. This lock has the following dimensions: length between hollow quoins of gates 270 ft., width at bottom 43 ft. 8 in., width at coping 45 ft. 3 in., depth of water over mitre sills 14 ft. It will accommodate vessels having the ordinary perpendicular and pointed bow and rounded stern up to an overall length of 255 ft.

The Welland canal connected Lake Erie with Lake Ontario, the difference in levels being 326½ ft. In 1887 this canal was in operation for 14-ft. navigation, locks 270 ft. long and 45 ft. wide. The normal time required to navigate the canal in 1930 was eighteen hours.

In 1913 work started on the Welland Ship Canal. The ship canal follows the valley of Ten Mile Creek between its mouth (Port Weller on Lake Ontario), about three miles east of Port Dalhousie, and Thorold. From Thorold to Port Colborne, the alignment has been changed in several places, and the canal now takes a much straighter course than that of the previous waterway. The general dimensions are as follows:—

| | |
|---|---|
| Length lake shore to lake shore | 27.6 miles |
| Minimum width of canal prism at 25-ft. depth | 200 ft. |
| Minimum width of canal prism at water level | 310 ft. |
| Minimum depth of canal prism | 25 ft. |
| Number of locks including Port Colborne Guard Lock | 8 |

Fig. 3—Locks 4 and 5, Welland Ship Canal.

| | |
|---|---|
| Length of guard lock | 1,386 ft. |
| Length of locks No. 1 to 7 inclusive | 859 ft. |
| Width of all locks | 80 ft. |
| Depth of water over sills of locks | 30 ft. |
| Lift of locks, except guard lock | 45.5 ft. |
| Normal time for a vessel to traverse the canal | 7.5 hrs. |

The construction of the Welland Ship Canal, which cost $132,070,236.46 to March 31st, 1936, was, of course, the outstanding work in waterway development in Canada during the period from 1887 to 1937, and a plan and profile of this canal has been included in this paper (see Fig. 1). Figures 2 and 3 show the S.S. *Lemoyne* passing through the waterway on the day of the official opening, August 6th, 1932. Figure 4 is a view of bridge 5, opened for the passage of the S.S. *Dow Chemical.* These illustrations give some idea of the magnitude of the work.

**Fig. 4—Bridge 5, Welland Ship Canal.**

During the period from 1887 to 1895 the Canadian canal at Sault Ste. Marie was constructed, with a lock 900 ft. long, 60 ft. wide and a normal depth of 18¼ ft. over sills, giving navigation through a Canadian lock from Lake Huron to Lake Superior.

### Other Canals

The Richelieu river to Lake Champlain route, commencing at Sorel on the St. Lawrence river, 46 miles below Montreal, extends along the River Richelieu through the St. Ours lock to Chambly Basin; thence by the Chambly canal to St. Johns, and up the river Richelieu to Lake Champlain. The distance from Sorel to the International Boundary is 81 miles. The maximum depth of water is normally 6 ft. 6 in. At Whitehall, at the southerly end of Lake Champlain, connection is made by means of the Champlain canal with the Hudson river which has 12 ft. draft available to Albany the head of ocean navigation. St. Ours lock (and dam) was rebuilt in 1930-32 and now has a depth of 12 ft.

The question of further improvements to this route is under consideration by the International Joint Commission.

In 1882-1889 the Murray canal was built through the Isthmus of Murray, giving connection westward between the Bay of Quinte and Presqu'ile Bay. The overall length of canal and entrance channels is 7.53 miles, depth 11 ft., with no locks.

The term "Trent canal" is applied to a series of navigable rivers and lakes connected by short canals forming a continuous system, with a minimum depth of 5 ft. 10 in. navigation, for 224 miles from the Bay of Quinte, Lake Ontario, to Swift Rapids on the Severn river. From the latter point vessels of smaller sizes can be passed over the marine railways, for a further distance of 16 miles to the outlet into Georgian Bay at Port Severn. Of the 240-mile route only 33¼ miles are artificial canal prism. The canal was completed, substantially as at present, in 1918.

### Red River

The St. Andrews lock and dam, built by the Department of Public Works, were opened for traffic in 1910. It is situated on the Red river 20 miles North of Winnipeg and 27.4 miles from Lake Winnipeg, providing through navigation with 9 ft. draft between the city and the lake. Lake Winnipeg is almost 300 miles long and covers 9,398 square miles, so that it is larger than Lake Ontario and only slightly less in area than Lake Erie. The St. Andrews lock and dam now provide a substantial link in one of the routes to the recently developed Gods Lake mining area.

### Mackenzie River

From the town of Waterways, about 300 miles north of Edmonton, Alberta (at the end of steel), a number of steam boats are operated in the District of Mackenzie. From Waterways by way of the Clearwater and Athabaska river, Lake Athabaska, the Rocher and Slave river navigation extends to Fitzgerald, Alta., at the head of a series of rapids extending to Fort Smith, N.W.T. This series of rapids is sixteen miles long, and at this point all the traffic must pass over a sixteen mile waggon road as the rapids are not navigable.

From Fort Smith, the boats operate on an unbroken chain of waterways, comprising the Lower Slave river, Great Slave lake and Mackenzie river to its mouth at Mackenzie bay on the Arctic ocean. The distance by water from Clearwater river to the Arctic coast is 1,662 miles.

From Norman on the Mackenzie river, traffic goes by Bear river to Great Bear lake, and by this route water transportation service is supplied to many mining properties, including the Eldorado gold mines at Labine Point, which is famous as a large producer of radium. Great Bear lake is the fourth largest lake on the continent.

The boats on the Mackenzie river have a draft of from 2 to 4 ft. and a capacity of from 70 to 225 tons. This shallow draft is necessary principally because of bars at the entrances to the large lakes. The season of navigation begins at Waterways about May 15th and the boats follow the ice down the river, reaching Aklavik at its mouth about June 17th. The last boat leaves for the south about September 1st, reaching Waterways early in October.

**Fig. 5—Peterborough Lift Lock, Trent Canal.**

During recent years there has been a considerable development of water traffic along the Mackenzie river, and since 1930 the Department of Transport has furnished a skeleton buoy and beacon service along this route, which is being increased as necessity requires.

### Principal Waterways Development 1887 and 1937

Table II gives a schedule of Waterways Development in Canada, 1887 and 1937, which shows clearly the facilities on the principal water transportation routes in 1887 and also in 1937.

On the routes shown in the schedule, the St. Andrews lock is under the Department of Public Works, while on the Mackenzie river no important development has been carried out. All the other developments are now under the Department of Transport, the St. Lawrence Ship channel having been under the late Department of Marine and the balance under the former Department of Railways and Canals, both of which are now merged in the Department of Transport.

### Traffic Carried and Cost to the Dominion

There are available very complete statistics of the traffic and expenditures on the canals under the old Department of Railways and Canals, and these comprise practically all the important inland waterways. Table III gives a schedule of Canal Traffic and Expenditures, which shows for each year 1887 to 1936 the traffic carried by these canals, the expenditures made, and the revenues received. The drop in revenues shown in 1904 is due to the abolition of canal tolls at that time, and the indirect revenues from canals since that date have been received principally from hydraulic and land rents. The indirect revenue of Canada for inland waterways development is almost incalculable, as the economical transportation afforded by water carriage is a primary factor in the industrial development of eastern Canada, and the agricultural development of western Canada.

The best index of the natural growth in waterways traffic, that is increased traffic not the result of improved facilities, is probably furnished by the St. Lawrence river canals. These waterways had a 9-ft. draft available in 1887 and during 1904 through navigation with a 14-ft. draft was furnished. They are not influenced materially by the heavy United States bulk freight traffic in coal and ore on the Great Lakes. Since 1904 there have been no major improvements between Montreal and Lake Ontario, nevertheless the traffic which amounted to 1,427,316 tons in 1904, that is with 14-ft. navigation, had increased to 8,411,542 tons in 1928, and this pre-depression maximum was almost equalled in 1936 with 8,288,416 tons. The traffic through the Welland canal has shown a correspondingly steady increase, being approximately equal in value to that of the St. Lawrence canals until 1930, when the improved facilities due to the opening of the Welland Ship Canal gave it a further decided increase. The construction of the St.

Fig. 6—"S.S. Distributor" at Aklavik, MacKenzie District.

Lawrence waterways, for which a treaty has been negotiated with the United States of America (subject to ratification by both countries), would enable full advantage to be taken by through traffic of the facilities provided by the Welland Ship Canal and a further corresponding increase in Welland Ship Canal traffic could then be expected.

Traffic through the Canadian Sault Ste. Marie canal reached a maximum of 42,699,324 tons in 1914 but since that date, owing to the diversion of traffic to the new American canal, it has only amounted to comparatively moderate proportions.

Traffic through the various secondary canals reached a maximum of 1,507,879 tons in 1910, and since then has shown a falling tendency with a moderate recovery from the low of 365,338 tons in 1933 to 467,692 tons in 1936.

Passenger traffic on canals reached a maximum of 320,574 passengers during 1910 and since then has fallen

Table II
Waterways Development in Canada—1887 and 1937

| Inland waterways | Location | 1887 | | | 1937 | | |
|---|---|---|---|---|---|---|---|
| | | Locks | | Normal depth | Locks | | Normal depth |
| | | Length | Width | | Length | Width | |
| St. Lawrence ship channel | Quebec to Montreal | | | 25 | | | 30 |
| Lachine canal | Montreal to Lachine | 270 | 45 | 12 | 270 | 45 | 14 |
| Beauharnois canal | Lake St. Louis to Lake St. Francis | 200 | 45 | 9 | Leased for power purposes 1908 | | |
| Soulanges canal | Lake St. Louis to Lake St. Francis | Constructed | 1892-1899 | | 280 | 46 | 15 |
| St. Lawrence canals | Lake St. Francis to Lake Ontario | 200 | 45 | 9 | 270 | 45 | 14 |
| Welland canal | Lake Ontario to Lake Erie | 270 | 45 | 14 | 859 | 80 | 25 |
| Sault Ste. Marie canal | Lake Huron to Lake Superior | Constructed | 1887-1895 | | 900 | 60 | 18 |
| Ottawa canals | St. Annes to Ottawa | 200 | 45 | 9 | 200 | 45 | 9 |
| Rideau canal | Ottawa to Kingston | 134 | 33 | 5 | 134 | 33 | 5 |
| Trent navigation | 1887 Various stretches | 133½ | 33 | 5 | | | |
| | Trenton to Rice Lake (1937) | | | | 154 | 33 | 8′ 4″ |
| | Rice Lake to Peterborough (1937) | | | | 122 | 33 | 7′ 8″ |
| | Peterborough to Swift Rapids (1937) | | | | 120 | 33 | 6′ 0″ |
| | Swift Rapids to Big Chute (Marine Railways) (1937) | | | | 60 | 13½ | 4′ 0″ |
| | Big Chute to Port Severn (1937) | | | | 100 | 25 | 6′ 0″ |
| River Richelieu | Sorel to Lake Champlain | 120½ | 23½ | 6½ | 120½ | 23½ | 6½ |
| St. Peters canal | Sea to Bras d'Or Lakes | 200 | 48 | 17 | 300 | 48 | 17 |
| St. Andrews lock and dam | Red River—Winnipeg to Lake Winnipeg | Constructed | 1897-1910 | | 215 | 45 | 9 |
| Mackenzie river | Waterways to Aklavik (Portage from Fitzgerald to Fort Smith 16 miles). | (Not developed) | | | No Locks | | 2 to 4 ft. |

off to a maximum of 38,493 in 1933 with recovery to 59,645 in 1936.

During the fifty years from 1887 to 1936, inclusive, the Dominion Government spent, through the Department of Railways and Canals, $199,213,819.36 on capital account for canals, $77,960,589.72 for maintenance and operation and received revenues amounting to $25,087,449.16.

During the same period about $68,000,000 was spent on improving the St. Lawrence River ship channel which, now, on account of increased depth required by the larger vessels navigating it, extends from Father Point to Montreal instead of from Quebec to Montreal as in 1887. Of this amount, $56,684,054.14 has been spent during the period July 1st, 1904, up to March 31st, 1936, that is since the ship channel was taken over from the Department of Public Works.

The St. Andrews lock and dam was built by the Department of Public Works at a capital cost of $1,569,776.99 to March 31st, 1936. During 1936, 10,063 tons of freight and 2,250 passengers were carried on this route.

### Special Features of Great Lakes Traffic

All statistics bring out prominently, that, in the Lake traffic, three great classes of freight predominate, viz. ore, coal and grains. These are shipped in bulk and to them must be added some other classes also handled in bulk. In effect, bulk freight now constitutes 98 per cent of the total, and the peculiar nature of this traffic has resulted in special developments which are to be seen nowhere else in the world. To give some idea of these, it need only be stated that no less than 12,508 tons of ore have been loaded into one vessel in the short space of sixteen and a half minutes. The same cargo of 12,508 tons was unloaded in

Table III
Canal Traffic and Expenditure—1887 to 1936

| Year | Freight Tons | | | | | Number of passengers | Expenditures (Exclusive of St. Andrews lock and dam) | | |
|---|---|---|---|---|---|---|---|---|---|
| | St. Lawrence | Welland | Sault Ste. Marie (Canadian lock only) | Other Canals, (Including St. Andrews lock and dam) | TOTAL | | Capital expenditure | Operating and maintenance cost | Revenue |
| 1887 | 886,982 | 777,918 | | 926,790 | 2,591,690 | 82,914 | $ 1,783,698.16 | $ 549,944.52 | $ 321,784.88 |
| 1888 | 781,599 | 878,800 | | 1,101,198 | 2,761,597 | 75,797 | 1,033,118.34 | 614,949.28 | 317,902.04 |
| 1889 | 919,872 | 1,085,273 | | 1,108,751 | 3,113,896 | 81,362 | 972,918.43 | 703,317.08 | 333,188.90 |
| 1890 | 853,853 | 1,016,165 | | 1,043,029 | 2,913,047 | 127,135 | 1,026,364.24 | 613,459.17 | 354,816.92 |
| 1891 | 936,314 | 975,013 | | 991,199 | 2,902,526 | 146,336 | 1,318,092.15 | 665,174.44 | 349,431.90 |
| 1892 | 966,775 | 955,554 | Sault Ste. | 1,109,427 | 3,031,736 | 152,439 | 1,437,149.30 | 718,334.73 | 324,475.24 |
| 1893 | 1,158,386 | 1,294,823 | Marie opened | 1,093,780 | 3,546,989 | 134,189 | 2,069,573.30 | 691,994.20 | 357,089.87 |
| 1894 | 886,778 | 1,008,221 | Aug. 1895 | 1,047,716 | 2,942,715 | 142,124 | 3,027,164.19 | 584,588.54 | 387,788.97 |
| 1895 | 828,228 | 869,595 | 595,837 | 1,042,418 | 3,336,078 | 156,588 | 2,452,273.65 | 661,568.33 | 339,890.49 |
| 1896 | 1,113,690 | 1,279,987 | 4,577,399 | 1,019,997 | 7,991,073 | 166,000 | 2,258,778.97 | 587,263.14 | 339,538.72 |
| 1897 | 1,231,365 | 1,274,292 | 4,947,063 | 1,108,247 | 8,560,967 | 157,682 | 2,348,636.91 | 557,561.57 | 384,780.53 |
| 1898 | 1,439,134 | 1,140,077 | 3,055,387 | 983,877 | 6,618,475 | 177,982 | 3,207,249.79 | 566,751.85 | 407,662.81 |
| 1899 | 1,349,093 | 789,770 | 3,006,664 | 1,080,397 | 6,225,924 | 213,710 | 3,899,877.31 | 565,146.53 | 369,044.38 |
| 1900 | 1,309,066 | 719,360 | 2,035,677 | 949,590 | 5,013,693 | 217,036 | 2,639,564.93 | 639,890.14 | 322,642.86 |
| 1901 | 1,208,296 | 620,209 | 2,820,394 | 1,016,360 | 5,665,259 | 190,428 | 2,360,569.89 | 712,471.68 | 315,429.69 |
| 1902 | 1,093,133 | 665,387 | 4,729,268 | 1,025,409 | 7,513,197 | 188,026 | 2,114,689.88 | 794,651.79 | 300,413.68 |
| 1903 | 1,681,206 | 1,002,919 | 5,511,868 | 1,007,824 | 9,203,817 | 236,823 | 1,823,273.61 | 959,499.32 | 230,213.15 |
| 1904 | 1,427,316 | 811,371 | 5,030,705 | 986,844 | 8,256,236 | 219,137 | 1,880,787.20 | 1,029,973.59 | *79,536.51 |
| 1905 | 1,752,855 | 1,092,050 | 5,473,406 | 1,053,433 | 9,371,744 | 233,545 | 2,071,593.72 | 1,186,097.82 | 78,009.21 |
| 1906 | 1,636,117 | 1,201,967 | 6,574,039 | 1,111,062 | 10,523,185 | 256,500 | 1,552,121.21 | 1,134,569.22 | 108,067.76 |
| 1907 | 2,100,466 | 1,614,132 | 15,588,165 | 1,240,876 | 20,543,639 | 279,199 | 887,838.61 | 871,383.84 | 105,003.15 |
| 1908 | 2,009,102 | 1,703,453 | 12,759,216 | 1,031,049 | 17,502,820 | 280,830 | 1,708,156.37 | 1,378,549.59 | 144,882.13 |
| 1909 | 2,410,629 | 2,025,951 | 27,861,245 | 1,422,923 | 33,720,748 | 272,222 | 1,868,834.45 | 1,608,777.87 | 199,501.26 |
| 1910 | 2,760,752 | 2,326,290 | 36,395,687 | 1,507,879 | 42,990,608 | 320,574 | 1,650,706.64 | 1,467,213.80 | 193,409.28 |
| 1911 | 3,105,708 | 2,537,629 | 30,951,709 | 1,435,307 | 38,030,353 | 304,904 | 2,349,474.49 | 1,368,370.81 | 221,138.49 |
| 1912 | 3,477,188 | 2,851,915 | 39,669,655 | 1,588,487 | 47,587,245 | 292,267 | 2,554,938.91 | 1,526,470.22 | 263,716.75 |
| 1913 | 4,302,427 | 3,570,714 | 42,699,324 | 1,481,448 | 52,053,913 | 335,799 | 2,255,448.21 | 1,433,344.49 | 307,567.66 |
| 1914 | 4,391,493 | 3,860,969 | 27,599.184 | 1.171,591 | 37,023,237 | 287,326 | 2,824,536.79 | 1,568,280.60 | 380,188.06 |
| 1915 | 3,409,467 | 3,061,012 | 7,750,957 | 977,367 | 15,198,803 | 250,836 | 5,490,796.03 | 1,644,176.26 | 427,763.14 |
| 1916 | 3,368,064 | 2,544,964 | 16,813,649 | 856,814 | 23,583,491 | 263,648 | 6,142,148.96 | 1,575,272.08 | 446,722.21 |
| 1917 | 3,391,144 | 2,490,542 | 15,447,092 | 910,157 | 22,238,935 | 244,819 | 4,304,589.09 | 1,558,292.74 | 461,423.14 |
| 1918 | 3,031,134 | 2,174,298 | 12,913,711 | 764,476 | 18,883,619 | 212,151 | 1,781,957.07 | 1,334,444.24 | 414,868.22 |
| 1919 | 2,891,619 | 2,170,779 | 4,138,085 | 794,783 | 9,995,266 | 262,056 | 2,211,935.48 | 1,569,573.22 | 387,654.90 |
| 1920 | 3,067,962 | 2,276,072 | 2,477,818 | 913,531 | 8,735,383 | 230,468 | 4,579,565.22 | 2,203,198.67 | 441,926.36 |
| 1921 | 3,734,065 | 3,076,422 | 1,997,592 | 598,942 | 9,407,021 | 230,129 | 5,449,961.68 | 2,841,211.69 | 365,941.36 |
| 1922 | 4,319,919 | 3,391,419 | 1,709,060 | 605,657 | 10,026,055 | 219,519 | 4,482,638.65 | 2,833,086.61 | 804,515.58 |
| 1923 | 4,541,528 | 3,755,912 | 2,255,929 | 646,065 | 11,199,434 | 220,604 | 4,995,184.27 | 2,332,813.44 | 742,404.13 |
| 1924 | 5,536,374 | 5,037,412 | 1,631,548 | 663,763 | 12,869,097 | 208,587 | 6,747,395.04 | 2,379,561.32 | 897,412.22 |
| 1925 | 6,206,988 | 5,640,298 | 1,634,970 | 648,411 | 14,130,667 | 208,692 | 10,619,902.69 | 2,258,547.80 | 907,650.33 |
| 1926 | 6,123,701 | 5,214,514 | 1,423,275 | 716,173 | 13,477,663 | 197,561 | 12,024,460.92 | 2,408,047.74 | 920,900.00 |
| 1927 | 7,912,952 | 7,247,459 | 1,470,551 | 857,349 | 17,488,311 | 210,884 | 13,845,683.78 | 2,416,632.68 | 961,694.09 |
| 1928 | 8,411,542 | 7,439,617 | 2,007,137 | 862,145 | 18,720,441 | 188,146 | 13.762,904.77 | 2,744,409.51 | 1,355,677.46 |
| 1929 | 5,718,651 | 4,769,866 | 2,374,119 | 837,011 | 13,699,647 | 164,552 | 13,164,582.26 | 2,515,330.79 | 1,230,332.55 |
| 1930 | 6,179,023 | 6,087,910 | 1,691,471 | 844,930 | 14,803,334 | 133,266 | 9,324,220.64 | 2,604,857.88 | 1,043,646.87 |
| 1931 | 6,036,980 | 7,273,886 | 2,219,567 | 658,641 | 16,189,074 | 126,633 | 12,945,771.20 | 3,699,981.00 | 1,026,670.83 |
| 1932 | 6,693,800 | 8,537,460 | 2,337,201 | 392,189 | 17,960,650 | 44,189 | 3,855,637.20 | 3,055,596.00 | 976,845.35 |
| 1933 | 6,951,064 | 9,194,130 | 2,269,957 | 365,338 | 18,780,489 | 38,493 | 3,122,026.00 | 2,799,793.00 | 831.020.30 |
| 1934 | 6,660,052 | 9,280,452 | 1,727,152 | 401,596 | 18,069,252 | 69,990 | 1,975,073.00 | 2,588,534.00 | 877,629.65 |
| 1935 | 6,873,655 | 8,953,383 | 1,932,047 | 446,904 | 18,205,989 | 56,473 | 464,004.00 | 2,554,982.00 | 837,870.70 |
| 1936 | 8,288,416 | 10,437,802 | 2,277.899 | 463,692 | 21,467,809 | 59,645 | 545,951.76 | 2,282,548.89 | 889,764.48 |
| Totals | 167,365,903 | 160,005,413 | 372,382,679 | 46,912,842 | 746,666,837 | 9,570,215 | $199,213,819.36 | $ 77,960,589.72 | $ 25,087,449.16 |

*Canal tolls abolished.

three hours and five minutes. Loading at the rate of 5,000 tons per hour is common. Vessels of the self-unloading type are used in the coal trade, and coal is loaded at rates up to 3,100 tons per hour. In loading grain an exceptionally fast rate was achieved at Port Arthur, where 355,000 bushels were loaded in five hours. Other figures are 130,000 bushels in one hour at Fort William, and 150,000 in seventy minutes (2,143 per minute) at the same point.

The boats plying in the bulk trade, on the Great Lakes, have steadily increased in size, and the largest vessels now carry 15,000 to 16,000 tons. Such vessels have a length of 633 ft. and a beam of 70 ft. and the number of 600 footers is constantly increasing and is now well over 300. Deck hatches are placed at 12-ft. or 24-ft. centres, the large boats having 36 or 38 hatches at 12-ft. centres. The machinery is right aft, and is usually steam, though motor vessels are increasing in number.

At the opening of the Welland Ship Canal, August 6th, 1932, the S.S. *Lemoyne*, 633 ft. long, 70 ft. beam, carried 530,000 bushels of grain or 15,900 tons, with a draft of 19 ft. 6 in. through the canal. Figures 2 and 3 refer to this particular movement.

During recent years there has been a very large development in the movement of gasoline and oil and package freight, both through the St. Lawrence River canals and on the Great Lakes. On account of the accompanying hazard gasoline and oil can be shipped much more cheaply by water than by rail while the extension of the area tributary to the waterways has been increased many times by motor transportation, thus extending this advantage to a much larger volume of package freight. Fifty years ago, in 1887, on the St. Lawrence canals 631,997 tons of freight moved east and 254,985 tons moved west or almost 3 to 1, while last year 1936, 4,093,041 tons of freight moved east, and 4,195,371 tons moved west, that is, the large wheat export moved amounting to 2,354,877 tons last year is more than balanced by upward freight.

### Conclusion

In a continental country such as Canada the importance of waterways in its development can hardly be overestimated. The great development of the prairie provinces is based for the provinces of Manitoba and Saskatchewan entirely, and to a lesser extent for Alberta, on the Great Lakes and St. Lawrence river. Without these waterways and their facilities the development of the western plains would have been impossible. Now the great waterways are lending their aid in the mining explorations of the Precambrian shield which covers so much of this country.

Fig. 7—Welland Ship Canal from Bridge 11.

# Hydro-Electric Progress

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**Fig. 1—Chaudiere Falls, Ottawa River, Site of First Hydro- Electric Installation in 1882. Present Installation 109,000 hp.; Plants Both Sides of River.**

At the World Power Conference held in Washington in September last, it was well said that—"Power has become the most efficient tool of the machine age, enormously lessening manual labour and quickening and rendering more efficient almost every productive activity." In Canada this basic tool is hydro power. Low-cost power has been Canada's key both to industrial progress and to the domestic comfort and well-being of its people.

This Semicentennial Celebration of The Engineering Institute of Canada affords a fitting opportunity to review the development of this basic instrument throughout the past fifty-year period. The opportunity is particularly appropriate inasmuch as the life of The Engineering Institute of Canada and its predecessor the Canadian Society of Civil Engineers covers almost the entire life of modern electricity.

Nature has been generous in its allotment and distribution of these water-power resources throughout the Dominion. The wide domain, favourable topography, ample and well distributed precipitation, and innumerable lakes and rivers all combine to provide a wealth of water-power resources which are capable of furnishing a dependable flow of low-cost hydro-electric energy to practically every centre of population in the Dominion and for the development of the industries of mine and forest in our great hinterland. This widespread availability of a low-priced power resource has been the basis of the remarkable development of the past fifty years and in this period has brought Canada from almost a purely agricultural country to one of outstanding industrial importance.

## HISTORICAL OUTLINE PRIOR TO 1887

Before proceeding with an outline of the growth of hydro-electric development and utilization in Canada during the past fifty years, it is desirable to sketch briefly the progress which had been made, prior to that period, in the knowledge and utilization of the two primary factors, electricity and water power.

### Electricity

The discovery of electro-magnetic induction was announced by Faraday in 1831 and led to the construction of alternating current dynamos. Practical progress was slow and it was over twenty-five years before these alternators were put to practical use for the arc lighting of lighthouses. At that time most electricians were accustomed to direct currents, so far as these were available from electro-chemical cells, and although a number of brilliant minds were delving into the theory of alternating currents the majority were thinking in the terms of direct currents and were awaiting a satisfactory generator. This was provided, in 1872, by the Gramme direct current dynamo. The fact that a dynamo would function as a motor if supplied with current was observed the following year.

The chief public familiarity with electricity in these early years was for lighting but, admirable though the arc lamp was, it was realized that a smaller and less intense illuminant was necessary. However, it was not until 1880 that an incandescent lamp was evolved which could be manufactured on a commercial basis. This lamp gave rise to the central station constructed to furnish power for lighting and, as in the daylight hours battery charging was the only load available, an impetus was provided for the development of motors and other devices for the daytime use of power. The first commercial electric tramway opened in 1881.

With so many minds engaged on the problem, logical conceptions of the magnetic circuit began to take shape and, about 1886, electrical progress began to evolve as an exact science. Electrical engineers began to acquire knowledge of the element with which they were dealing and to adapt other machines and materials to their needs.

The high speed necessary for dynamo driving led to the development of high speed prime-movers and we read that in 1887—the beginning of the period we are reviewing—Parsons produced a small steam turbine-dynamo set which was used to light the Exhibition at Newcastle, England.

While direct current was more popular at this time, the alternator had powerful supporters, particularly on this continent, and there were many alternating systems of lighting.

In 1887 then, although much ground work had been accomplished, the practical achievements were not yet remarkable. A 500 hp. dynamo was a colossus; transmission was restricted to two or three miles; aluminum was an interesting laboratory material available in small quantities only and at great expense, the Hertzian wave, Roentgen ray, wireless, Diesel engine and a great many other necessities of nowadays existence had not yet been heard of. In fact, in 1887, electricity was more or less confined to the telegraph and cable, a few telephones, a small but growing lighting business and a few electric tramways.

### Hydro Power

Water has been used as a source of energy since the earliest times. In early Canadian settlement, long before the advent of electricity, the use of small heads on rivers and streams throughout the settled areas, by means of wooden water-wheels of various design, formed the driving power for the operation of saw mills, grist mills, and other local industries. The earliest known development was made about 1607 by the early French settlers to drive a small mill near Annapolis Royal in Nova Scotia at the mouth of the Lequille river.

Even today we find large and important industries located in areas in which they were originally established to utilize the power of some now almost forgotten creek. In Canada, early routes of travel were by waterway and, as was natural, early settlements grew up on these waterways and promptly availed themselves of any nearby fall to operate local industries.

When the dynamo was first invented it was quickly realized that water turbines, which had already been developed, were extremely suitable for their operation and the hydro-electric relationship was early established. Fifty years ago there were already a number of hydro-electric plants in Europe and the United States whilst

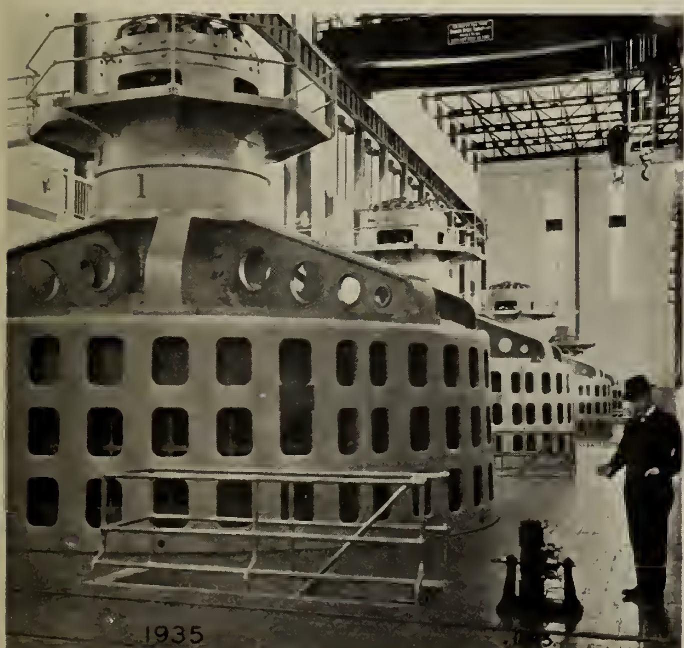


**Fig. 2—1.6 hp. Dynamo, Installed 1885, Compared with Modern 34,000-hp. Generators, Chelsea Plant, Gatineau Power Company.**

a beginning had been made in Canada. The earliest recorded utilization was the lighting of Young's saw mill at Ottawa in 1882.

In these early days electrical power transmission was not available for more than a mile or so and many engineers still favoured tele-dynamic, hydraulic or pneumatic means of transmission. It was not until 1891 that an experimental transmission of 300-hp. 3-phase alternating current at 16,000 volts (later raised to 30,000 volts) for a distance of 112 miles was made in Germany and drew the comment in an electrical journal of the time that "Since the transfer of work by electrical means has become an actual fact, the question of the transmission of power to great distances, especially by the use of remote water-powers comes more and more to the front." Though this comment was made in 1891 there


**Fig. 3—De Cew Falls, Welland Canal, in operation 1898. Installed Capacity now 45,000 hp. H.E.P.C. of Ont.**

still remained much to be done to develop reliable equipment capable of dealing with high voltages and, step by step, transmission voltages and distances gradually increased.

### OUTLINE OF GROWTH—1887-1937

Turning to the actual fifty-year period under review, it has been noted that, in the early years, interest was developing in the application of hydro power to the generation of electricity.

By 1887, public distribution was in progress in Ottawa, Cornwall, Peterborough, Sault Ste. Marie and Pembroke in Ontario and in Quebec and Hull in Quebec

During the period 1887-1900, distribution of hydro-electric power at generator voltage continued where conditions were favourable. In 1893 the International Railway Company installed two 1,000 hp. units at Niagara Falls to operate its electric tramway and to supply electric light and power for distribution. The following year, 1894, three units of the same size were installed at Montmorency Falls to replace an earlier installation, the power being transmitted for distribution in Quebec city, seven miles distant.

In 1897, following the development of the electrical transformer, the first long distance transmission in Canada and, it is believed, in the British Empire, was initiated when a 1,200-hp. development was completed on the Batiscan river and power transmitted 18 miles at 11,000 volts to Three Rivers, Quebec. This heralded the inauguration of modern hydro-electric development in the Dominion. Other systems soon followed: Montreal received power from Lachine and Chambly; Hamilton, Ontario, from DeCew falls; Victoria, British Columbia, from the Goldstream river and Nelson, British Columbia, from the Kootenay river, all in the year 1898. By the end of 1900, water-power installation had reached a total of 173,000 hp.

The next decade, 1900-1910, witnessed a very substantial increase in development, the installation at the end of 1910 having reached a total of 977,000 hp. This was a net increase for the period of more than 803,000 hp., more than a quarter of which was installed in three

TABLE I

CANADIAN WATER POWER DEVELOPMENT

Total turbine installation at the end of each year shown

| | 1900 | 1901 | 1902 | 1903 | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 | 1917 | 1918 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| British Columbia | 9,366 | 9,366 | 13,266 | 20,346 | 26,396 | 29,334 | 45,816 | 58,570 | 58,610 | 63,048 | 64,474 | 119,393 | 165,838 | 224,680 | 252,690 | 254,265 | 288,330 | 297,169 | 307,533 |
| Alberta | 280 | 280 | 280 | 355 | 355 | 355 | 355 | 355 | 655 | 655 | 655 | 14,855 | 15,035 | 32,835 | 33,110 | 33,110 | 33,110 | 33,122 | 33,122 |
| Saskatchewan | | | | | | | | | | | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 35 |
| Manitoba | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 38,800 | 38,800 | 38,800 | 38,800 | 38,800 | 64,800 | 64,800 | 64,800 | 78.850 | 78,850 | 78,850 | 78,850 | 85,325 |
| Ontario | 53,876 | 62,788 | 77,022 | 79,909 | 111,697 | 202,896 | 279,028 | 345,404 | 410,079 | 437,613 | 490,821 | 634,263 | 659,190 | 751,545 | 858,534 | 871,309 | 921,158 | 955,955 | 981,313 |
| Quebec | 82,864 | 139,149 | 152,783 | 164,258 | 179,468 | 183,799 | 205,211 | 242,582 | 269,814 | 305,556 | 334,763 | 468,977 | 513 635 | 551,871 | 664,139 | 803,786 | 836,394 | 856,769 | 905,303 |
| New Brunswick | 4,601 | 4,601 | 4,636 | 7,427 | 8,459 | 8,594 | 10,134 | 10,172 | 10,407 | 10,507 | 11,197 | 13,635 | 15,185 | 15,185 | 15,380 | 15,405 | 15,480 | 16,251 | 16,311 |
| Nova Scotia | 19,810 | 20,132 | 21,944 | 23,518 | 26,228 | 26,563 | 26,952 | 27,977 | 28,419 | 29,381 | 31,476 | 32,226 | 32,773 | 32,964 | 33,469 | 33,596 | 33,656 | 34,051 | 34,318 |
| Prince Edward Island | 1,521 | 1,581 | 1,641 | 1,641 | 1,641 | 1,663 | 1,701 | 1,701 | 1,701 | 1,734 | 1,760 | 1,760 | 1,785 | 1,825 | 1,843 | 1,942 | 1,962 | 1,989 | 2,198 |
| Yukon | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2,085 | 2,095 | 3,195 | 3,195 | 13,195 | 13,195 | 13,195 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 |
| CANADA | 173,323 | 238,902 | 272,577 | 298,459 | 355,249 | 454,209 | 608,002 | 727,646 | 820,580 | 890.489 | 977,171 | 1.363.134 | 1,481,466 | 1,688,930 | 1,951,244 | 2,105,492 | 2,222,169 | 2,287,385 | 2,378,657 |

| | 1919 | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| British Columbia | 308,364 | 309,534 | 310,262 | 329,557 | 356,118 | 360,492 | 443.852 | 463,852 | 475,232 | 554.792 | 559,792 | 630,792 | 655.992 | 713,792 | 717,602 | 717,717 | 718,497 | 718,922 | |
| Alberta | 33,122 | 33,122 | 33,122 | 33,122 | 33,122 | 34,532 | 34,532 | 34,532 | 34,532 | 34,532 | 70,532 | 70,532 | 70.532 | 71,597 | 71,597 | 71,597 | 71,597 | 71,597 | |
| Saskatchewan | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 42,035 | 42,035 | 42,035 | 42,035 | 42,035 | 42,035 | 42,035 | |
| Manitoba | 85,325 | 85,325 | 99,125 | 134,025 | 162,025 | 162,025 | 183,925 | 227,925 | 255,925 | 311,925 | 311,925 | 311,925 | 390,925 | 390,925 | 390,925 | 390,925 | 392,825 | 392,825 | |
| Ontario | 1,036,550 | 1,057,422 | 1,165,940 | 1,305,536 | 1,396,166 | 1,595,396 | 1,802,562 | 1,808,246 | 1,832,655 | 1,903,705 | 1,952,055 | 2,088,055 | 2,145,205 | 2,208,105 | 2,355,105 | 2,355,755 | 2,560,155 | 2,561,905 | |
| Quebec | 936,903 | 955,090 | 1,050,338 | 1,099,404 | 1,135,481 | 1,312,550 | 1,749,975 | 1,886,042 | 2,069,518 | 2,387,118 | 2,595,430 | 2,718,130 | 3,100,330 | 3,357,320 | 3,493,320 | 3,703.320 | 3,853,320 | 3,883,320 | |
| New Brunswick | 19,126 | 21,976 | 30,976 | 42,051 | 43,101 | 44,521 | 42,271 | 47,131 | 47,131 | 67,131 | 112.631 | 133,681 | 133,681 | 133,681 | 133,681 | 133,681 | 133,681 | 133,681 | |
| Nova Scotia | 35,193 | 37,623 | 48,908 | 49,142 | 50,331 | 65,572 | 65,637 | 66,147 | 68,416 | 74,356 | 109,124 | 114,224 | 111,999 | 112,167 | 112,167 | 116,367 | 116,367 | 120,667 | |
| Prince Edward Island | 2,233 | 2,233 | 2,252 | 2,274 | 2,274 | 2,274 | 2.274 | 2,274 | 2,274 | 2,439 | 2,439 | 2,439 | 2,439 | 2,439 | 2,439 | 2,439 | 2,439 | 2,439 | |
| Yukon | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 13,199 | 18,199 | 18,199 | |
| CANADA | 2,470,050 | 2,515,559 | 2,754,157 | 3,008,345 | 3,191,852 | 3,590,596 | 4,338,262 | 4,549,383 | 4,798,917 | 5,349,232 | 5,727,162 | 6,125,012 | 6,666,337 | 7,045,260 | 7,332,070 | 7,547,035 | 7,909,115 | 7,945,590 | |

The Queenston Power House of the Queenston-Chippawa Development. Its completed length, to house the ten main units and two service units which it now contains, exceeds 590 feet and operates under a head of 294 feet. If the building were placed in front of the American Falls it would nearly hide them. The total capacity of the development is 550,000 horse power.

*Illustration through the Courtesy of*
The Hydro-Electric Power Commission
of Ontario

Fig. 4—Shawinigan Falls, St. Maurice River, Que., No. 1 Plant started 1902, present Installation Plants 1 and 2, 278,500 hp. S.W. and P. Co.

hydro-electric stations at Niagara Falls from which power was first transmitted to Toronto in 1906. At Shawinigan Falls the Shawinigan Water and Power Company installed its initial units in 1901, and in 1903 power was transmitted to Montreal supplementing the supply already being received from Lachine and Chambly. Fort William, Ontario, received power from the Kakabeka Falls plant of the Kaministiquia Power Company in 1906 and in the same year the Winnipeg Electric Railway Company brought hydro-electric power to Winnipeg from its plant on the Winnipeg river. Vancouver received its first supply of hydro-electric power in 1904 from the first Coquitlam-Buntzen plant of the Vancouver Power Campany, and the mining district in and around Rossland, British Columbia, was supplied by the West Kootenay Power and Light Company from the Kootenay river in 1906.

The decade 1910-1920 showed an increase in development of 1,538,000 hp., more than sixty-two per cent of which took place in the first four years. The growth in the last six years was retarded by war and post-war conditions The period is notable as marking the commencement of power delivery by the Hydro-Electric Power Commission of Ontario, which took place in October 1910 with the bringing into operation of a line extending from Niagara to Kitchener. The Commission secured its first supply by purchase from plants at Niagara Falls, but in 1914 commenced the production of power by building a small plant at Wasdells Falls which was quickly followed by others and in 1917, construction was begun on the great Chippawa-Queenston project, from which power was first delivered in 1922. The installations in the period 1910-1920 included substantial additions to existing stations at Niagara Falls, Shawinigan Falls and elsewhere, while several large new undertakings were completed including developments at Cedars rapids and at St. Timothee on the St. Lawrence, at Grand'Mere on the St. Maurice, in the Lake St. John district in Quebec, at Pointe du Bois on the Winnipeg river and on the Jordan river in British Columbia.

In the next decade, 1920-1930, water-power development far outdistanced anything that had gone before. In this ten-year period, installations totalling more than 3,609,000 hp. were brought into operation. Among the many developments included in this total were such large stations as the Queenston plant of the Hydro-Electric Power Commission of Ontario with 560,000 hp., the 495,000-hp. plant of the Duke-Price Power Company on the Saguenay river, the three Gatineau river plants of the Gatineau Power Company with installations totalling 436,000 hp., the 120,000-hp. plant of the Shawinigan Water and Power Company at La Gabelle on the St. Maurice, the Great Falls plant of the Manitoba Power Company on the Winnipeg river with 168,000 hp., two new plants of the West Kootenay Power and Light Company on the Kootenay river in British Columbia totalling 135,000 hp., the 90,000-hp. plant at High Falls of the MacLaren Quebec Power Company on the Lievre river, the 47,000-hp. plant of the British Columbia Power Corporation at Ruskin on the Stave river, the 42,000-hp. plant of the Churchill River Power Company at Island Falls, the 54,000-hp. Alexander development on the Nipigon river of the Hydro-Electric Power Commission of Ontario, and many others.

Finally in the period 1930-1937, development fell under the influence of conditions brought about by the world-wide economic depression. This period witnessed the initiation of very few new developments of magnitude but in these six years a number of large undertakings, commenced before the depression, were brought to completion. The total increase in installation was 1,820,000 hp. including such developments as the 260,000-hp. plant of the Alcoa Power Company on the Saguenay river, the 224,000-hp. plant at Chats Falls on the Ottawa river jointly owned by the Hydro-Electric Power Commission of Ontario and the Ottawa Valley Power Company, the 330,000-hp. development of the Ontario Government at the canyon on the Abitibi river, the 400,000-hp. plant of the Beauharnois Light, Heat and Power Company on the St. Lawrence, the Rapide Blanc plant of the Shawinigan Water and Power Company on the St. Maurice of 160,000 hp., the 136,000-hp. Masson plant of the MacLaren Quebec Power Company on the Lievre river, the 57,000-hp. Corra Linn plant of the West Kootenay Power and Light Company on the Kootenay river, the Seven Sisters plant of the Northwestern Power Company on the Winnipeg river with 55,000 hp. installed, the Slave Falls plant of the city of Winnipeg on the same

Fig. 5—Coquitlam-Buntzen Development No. 1 of British Columbia Power Corp. first operated 1904, Present capacity 43,500 hp., Head 395 ft.

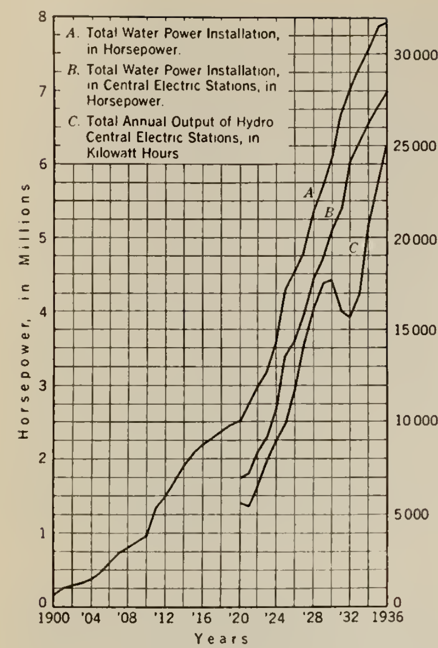



Fig. 6—Growth of Water Power Installation in Canada, Hydro installation in Horsepower, and Output in kw.h. of Central Electric Stations.

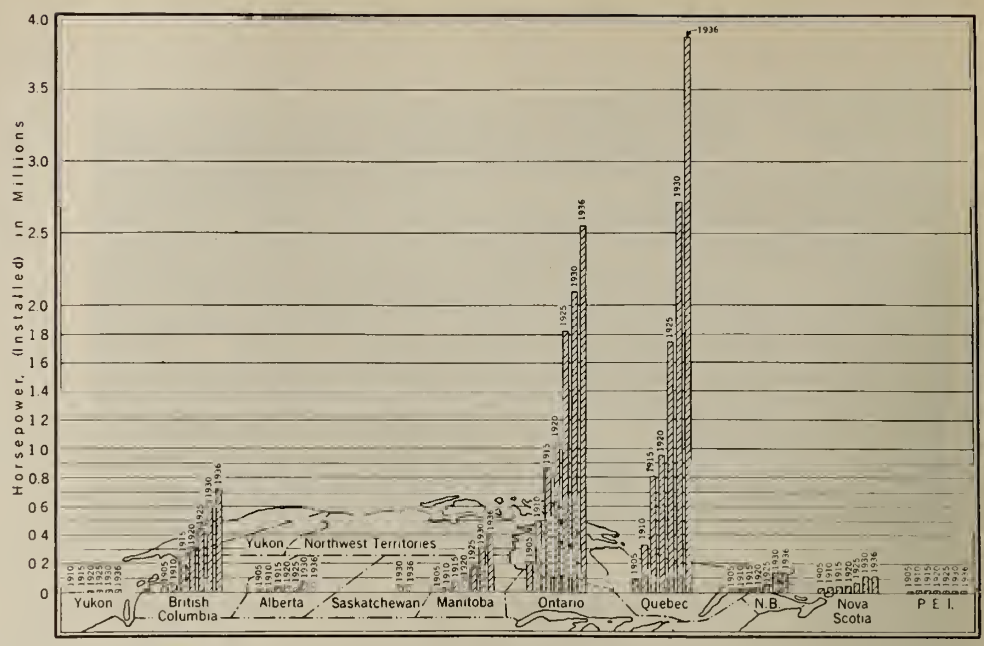



Fig. 7—Growth of Water Power Development in Canada by Provinces.

river with an initial installation of 24,000 hp., and numerous other lesser plants and additions to existing stations.

This brief review gives but a bare outline of the great water-power development that has taken place in the past fifty years. Figures for the earlier years of the period are indefinite but a quite accurate record is available from 1900 onward. This is given in Table I which shows the figures of installation at the end of each year from 1900 to 1936 for each province and for the Dominion as a whole. The growth is also shown graphically by provinces and for the Dominion in Figs. 6 and 7. It is seen that from a modest beginning of 173,000 hp. in 1900 the total had grown at the end of 1936 to a figure of 7,945,000 hp.; a very remarkable achievement.

The series of photographs accompanying this paper are illustrative of typical power installations brought into operation throughout the period under review. Particular attention is called to the photograph showing a row of modern 34,000-hp. vertical type water-wheel driven generators in the Chelsea plant of the Gatineau Power Company and, alongside, the little dynamo of 1.2 kw. used at the same site to operate two arc lamps half a century ago. This photograph which epitomizes fifty years of progress was kindly furnished by John Murphy, M.E.I.C., of Ottawa.

## WATER-POWER DEVELOPMENT IN THE PROVINCES

The growth in the utilization of water-power in the various provinces has been influenced by many factors, the dominating one, of course, being the availability of such water powers to existing and prospective markets. These markets are chiefly the centres of population where domestic, commercial and general manufacturing requirements provide an ever increasing demand for low-cost power, the pulp and paper industry which is by far the largest consumer of power and the mining, metallurgical and electro-chemical industries. It is not proposed to deal with progress in water-power development in the provinces in detail but to give very briefly an indication of the outstanding features.

### British Columbia

Water-power development in British Columbia has grown up chiefly in the Victoria, Vancouver and Nelson districts although there have been, in addition, substantial installations elsewhere for municipal, pulp and paper and mining purposes. With little more than 9,000 hp. installed in 1900 the total had increased to 64,000 hp. in 1910, to 309,500 hp. in 1920, to 631,000 hp. in 1930 and 719,000 hp. at the end of 1936

The Vancouver and Victoria districts are served by the British Columbia Power Corporation. The Vancouver district has been progressively supplied first in 1904 from the Coquitlam-Buntzen developments on Burrard Inlet, then from Stave Falls in 1912, from the Alouette station in 1927 and finally from the Ruskin station on Stave river in 1930. These five stations have a combined installation of 219 000 hp. The Victoria district received its first power from the Goldstream station in 1898 followed by power from two stations on the Jordan river. The three stations now have an installed capacity of 42,400 hp.

Fig. 8—Pinawa Channel Plant, Winnipeg River, Man. In operation 1906, with 37,800 hp. Winnipeg Electric Co.

In the Nelson and southern boundary district, power is supplied chiefly from four plants on the Kootenay river of the West Kootenay Power and Light Company. From a small beginning in 1897 with a plant of 2,368 hp. at Lower Bonnington Falls additional plants have been progressively added at Upper Bonnington, South Slocan and Corra Linn until at present they have a combined capacity of 226,000 hp. In addition, the city of Nelson has its own plant at Upper Bonnington with a capacity of 6,570 hp.

**Fig. 9—Pointe du Bois Falls, Winnipeg River, Man. City of Winnipeg Plant in operation 1911. Present Capacity 105,000 hp.**

The Fernie and Eastern boundary district is served by the East Kootenay Power Company from two plants, one of 7,200 hp. on the Bull river installed in 1922 and the other on the Elk river with 15,000 hp. installed in 1923. An auxiliary fuel station with a present installation of 12,500 kva. was erected at Sentinel, Alberta in 1927.

Elsewhere in the province, smaller systems or individual developments bring the benefits of hydro-electric power to municipalities and industries. Kamloops, Nanaimo, Revelstoke and Prince Rupert are served in this way, while large pulp and paper mills at Powell river and Ocean Falls and numerous mining centres are also supplied with hydro power.

### Alberta

Hydro-electric development in Alberta began at an early date with a 270-hp. development on the Bow river in Calgary in 1893. No appreciable increase, however, took place until 1911 when the Calgary Power Company brought its first plant into operation at Horseshoe falls on the Bow river with an installation of 20,000 hp. The Company's second plant of 11,600 hp. at Kananaskis falls on the same river followed in 1913 and a third plant also on the Bow came into operation in 1929 with 36,000 hp. The Company also controls a 780-hp. development in Calgary and has a widespread transmission system serving about one hundred municipalities from Edmonton to the United States border. Several other small developments, notably those at Banff and Lake Louise, make up with the Calgary Power Company's plants the total for the province of 71,597 hp.

### Saskatchewan

The only hydro-electric development of note in Saskatchewan is that at Island Falls on the Churchill river where in 1930 an installation of 42,000 hp. was made by the Churchill River Power Company to furnish power to the Flin Flon mining area on the Manitoba-Saskatchewan boundary, distant about 60 miles from the plant. A further unit is being installed in 1937 which will bring the total installation to 61,500 hp.

The southern and populous part of Saskatchewan is one of the few areas in the Dominion where conditions for water-power development are not commercially favourable. As a result, the power needs in this area are met from fuel-power stations.

### Manitoba

Water-power development in Manitoba began in 1900 with an installation of 1,000 hp.; by 1910 this had grown to 38,800 hp., to 85,300 hp. in 1920, to 312,000 hp. in 1930 and at the end of 1936 had reached a total of 393,000 hp.

The first development, one of 1,000 hp. on the Minnedosa river, was made in 1900. This was operated seasonally, usually from April to November, and in conjunction with a steam station served the city of Brandon. The plant has not been used since 1924.

In Winnipeg, fuel power supplied the needs of the community from 1892 until 1906 when the first hydro-electric plant was brought into operation at Pinawa on the Winnipeg river with an installation of 37,800 hp. This plant of the Winnipeg Electric Company inaugurated a programme of development on the Winnipeg river which has not only met the expanding power needs in Winnipeg but has been extended to serve almost the entire southern part of the province and the mining district in central Manitoba.

The second plant came into operation in 1911 when the city of Winnipeg completed an initial installation of 26,000 hp. at Pointe du Bois to which additions were made from time to time until in 1926 the plant reached its ultimate capacity of 105,000 hp. In 1922 the Winnipeg Electric Company through a subsidiary brought into operation a development at Great Falls which reached its final installed capacity of 168,000 hp. in 1926. Through another subsidiary the company's third development at Seven Sisters Falls commenced operation in 1930 with an initial capacity of 55,000 hp.; the ultimate installation to be 225,000 hp. In the next year the city of Winnipeg's

**Fig. 10—Stave Falls, Stave River, B.C. Completed 1912. Present installed Capacity 77,500 hp. B.C. Power Corp.**

second plant at Slave Falls started delivery of power with a capacity of 24,000 hp. This is being enlarged to 36,000 hp. in 1937 and the plant has a designed capacity of 96,000 hp.

In the north-eastern part of the province the Gods Lake Gold Mining Company in 1935 completed a 1,900-hp. installation at Kanuchuan rapids on Island Lake river to serve its mining property with power.

Power distribution in Winnipeg and its environs is carried out by the city of Winnipeg and the Winnipeg Electric Company. Elsewhere in the province the Manitoba Power Commission, created in 1919, maintains a widespread and growing transmission system. The power supply for this system is mainly derived by purchase from the plants on the Winnipeg river supplemented by a small hydro plant of 125 hp. at Minnedosa and several small fuel plants.

Fig. 11—Cedars Rapids, St. Lawrence River, Que. M.L.H. and P. Co. In Operation 1914. Present installed Capacity 197,400 hp.

### Ontario

Water-power has been utilized in Ontario since the days of pioneer settlement but it is only during the present century that extensive development has taken place. In 1900 the total installation in the province had reached a figure of about 54,000 hp., much of which was applied mechanically in many small industrial establishments. The stimulus of electrical development increased this total to 491,000 hp. in 1910, and the figures rapidly grew to 1,057,000 hp. in 1920, to 2,088,000 hp. in 1930 and in 1936 had reached a total of 2,562,000 hp.

In southern Ontario many of the cities and towns received their early supplies of electric energy from fuel-power plants, as hydro-electric plants were limited in scope until the advent of long distance transmission.

At Niagara Falls all the early developments were made by private companies with most of the power being exported to the United States. The Canadian Niagara Power Company's plant came into operation in 1904 with 10,250 hp. and with later enlargements reached an ultimate capacity of 121,000 hp. The Ontario Power Company's plant followed with an initial installation of 34,800 hp. in 1905, later to reach a total of 208,200 hp. Then the Toronto Power Company brought its plant into operation in 1906 and following systematic additions reached a total installed capacity of 164,500 hp. Adjacent to Niagara on the Welland canal a subsidiary of the Dominion Power and Transmission Company had brought its plant at DeCew falls into operation in 1898 with 3,000 hp., later to reach a total of 45,000 hp. Power from these plants served a limited area in Ontario including the city of Hamilton and certain municipalities in the Niagara peninsula with service eventually being extended to Toronto in 1906.

In 1906 the Hydro-Electric Power Commission of Ontario was established—a public ownership enterprise which was to become one of the greatest power distributing undertakings in the world. From then on, the Commission's activities dominated all others in southern Ontario. Transmission lines were constructed and distribution to the municipalities commenced in the autumn of 1910, the power being purchased from Niagara. Fuel power stations were rapidly superseded as hydro-electric energy spread throughout the south-western peninsula from Toronto to Windsor. The Commission completed its first development at Wasdells Falls on the Severn river in 1914, the Big Chute plant on the Severn was purchased in the same year, the Eugenia plant on the Beaver river was completed in 1915, plants on the Trent, Muskoka and South rivers were taken over in 1915 and 1916, control of the Ontario Power Company at Niagara was acquired in 1917, the great Queenston enterprise at Niagara was started in the same year, brought into operation in 1922 and finally completed with an installed capacity of 560,000 hp. in 1930; the Toronto Power Company's plant was purchased in 1922, that of the Dominion Power and Transmission Company in 1929, the Chats Falls plant on the Ottawa river was brought into operation in 1930-31 with an installed capacity of 112,000 hp. and numerous other plants were either built or acquired by purchase on the Muskoka, South, Mississippi, Madawaska

Fig. 12—Iroquois Falls, Abitibi River, Ont. Installed 1914. Present Capacity 28,000 hp. Abitibi P. and P. Co.

Fig. 13—Eugenia Falls, Beaver River, Ont., H.E.P.C. of Ont. Installed 1915. Present Capacity 8,500 hp. Head 549 ft.

and other rivers. At the present time the Commission has, in that part of the province south of North Bay, almost a monopoly of power distribution with a total installation of more than 1,190,000 hp. supplemented by a substantial amount of purchased power from companies in Quebec province.

Apart from the Commission's plants in southern Ontario there are a number of municipally and privately owned plants such as those of the town of Orillia on the Severn and Gull rivers, the town of Almonte on the Mississippi, the town of Campbellford on the Trent, Parry Sound on the Seguin river, the Canadian Niagara Power Company at Niagara Falls, the Ottawa Electric Company on the Ottawa river, the St. Lawrence Power Company at Cornwall and several others

In northern Ontario, hydro-electric development has taken place chiefly in connection with mining and the pulp and paper industry. While much of this development has been made by private enterprise, the activities of the Hydro-Electric Power Commission have been increasingly extensive both in plants it has itself constructed and those it has built and operated in behalf of the Ontario Government. On the Nipigon river the Commission has two plants, Cameron Falls brought into operation in 1920 and later enlarged to 75,000 hp. and Alexander Falls with 54,000 hp. completed in 1930. Power from these plants goes to Fort William and Port Arthur and also to the gold-mining district east of Lake Nipigon. In the Sudbury district, three plants totalling 16,900 hp. on the Wanapitei river were acquired in 1929 and have since been operated by the Commission to serve Sudbury and the adjacent copper-nickel mining area with power. Similarly in 1933 the Ontario government acquired a plant under construction at the canyon on the Abitibi river. This was brought into operation by the Commission as agent for the government in the same year and completed in 1935 with an aggregate installation of 330,000 hp. Power goes from the canyon plant to Sudbury and to the mines in the Porcupine and Kirkland Lake mining areas. The Commission also constructed and operates plants for the government at Ear falls on the English river and at Rat rapids on the Albany river to supply power to adjacent gold-mining areas. The Ear Falls plant of 5,000 hp. was brought into operation in 1929 and is being doubled in 1937. The Rat Rapids station, built in 1934-35 and enlarged in 1936, has a total capacity of 2,950 hp.

Under private enterprise the principal developments in northern Ontario are as follows: At Kenora at the outlet of Lake of the Woods a plant established in 1892 and replaced in 1906 was purchased by the Keewatin Power Company in 1922. The plant was enlarged in 1923-24 and a second station built in 1924-25; the combined installation being 30,875 hp. The power is sold for municipal purposes and for the operation of paper mills. At Fort Frances the Ontario and Minnesota Power Company built a plant on the Rainy river in 1910 where the installation now aggregates 15,350 hp. and later in 1927-28 constructed three plants on the Seine river with capacities totalling 36,500 hp., this power is largely used to supply pulp and paper mills. At Fort William the Kaministiquia Power Company developed power at Kakabeka Falls in 1906 and has now an installed capacity of 35,000 hp. At Sault Ste. Marie the Great Lakes Power Company acquired a development first installed about 1901 and has carried out reconstruction which gives the plant a present capacity of 29,200 hp. The company also has a plant of 22,000 hp. on the Michipicoten river completed in 1930 and one of 10,000 hp. on the Montreal river brought into operation in 1937. Power is used for municipal supply and for steel and paper mills at Sault Ste. Marie, also for mining in the Michipicoten and Goudreau districts. The International Nickel Company has five stations on the Spanish and Vermilion rivers aggregating 63,100 hp. These were progressively installed from 1905 to 1929 and serve the company's mines and smelters with power. The Canada Northern Power Corporation has nine stations on the Montreal, Metabetchouan and Mattagami rivers with an aggregate installation of 106,340 hp. serving the mines in the Cobalt, Gowganda, Porcupine, Kirkland and Larder Lake areas. The first of these developments was made in 1910 and the last in 1930. The Abitibi Power and Paper Company has eight plants, three on the Abitibi river, two on the Sturgeon, one on the Spanish, one on the Mattagami and one at Sault Ste. Marie with installations totalling 176,340 hp. The Spruce Falls Power and Paper Company has a 2,500-hp. plant on the Kapuskasing river and a 56,250 hp. plant at Smoky Falls on the Mattagami river completed in 1928.

**Fig. 14—Grand'Mere, St. Maurice River, Que. Installed 1916. Present Capacity 188,500 hp. S.W. and P. Co.**

**Fig. 15—Drummondville, St. Francis River, Que. In Operation 1919. Capacity now 19,500 hp. Southern Can. Power Co.**

### Quebec

Water-power development in Quebec exceeds that of any other province. As in other parts of eastern Canada, water powers have been utilized since the early days of settlement but the great growth has occurred in the present century. In 1900 the installed capacity had reached a total of almost 83,000 hp. This grew to 335,000 hp.

Fig. 16—Cameron Falls, Nipigon River, Ont. H.E.P.C. of Ont. Installed 1920. Present Capacity 75,000 hp.

in 1910, to 955,000 hp. in 1920, to 2,718,000 hp. in 1930 and at the end of 1936 aggregated 3,883,000 hp.

Practically all this development has taken place in the St. Lawrence river watershed, the major undertakings being on the St. Lawrence itself, on the Ottawa and its principal tributaries, on the St. Maurice, the Saguenay and its tributaries, and on the Richelieu and St. Francis rivers.

In the city of Montreal and on Montreal Island, power is distributed by Montreal Light, Heat and Power Consolidated from plants of its own and from power purchased from other companies. Its first plant at Lachine came into operation in 1898 with 10,000 hp. later enlarged to 15,800 hp., the Chambly plant on the Richelieu followed in 1901; this has a present capacity of 31,600 hp.; then the Soulanges plant was installed in 1906 with 5,350 hp. later increased to 16,050 hp. and finally the Cedars plant on the St. Lawrence came into operation in 1914 with 97,200 hp., later to be enlarged to 197,400 hp. Latterly the Lachine and Soulanges plants have been inactive.

Other plants in the vicinity of Montreal selling power to Montreal Light, Heat and Power Consolidated are those of the Canadian Light and Power Company at St. Timothee on the St. Lawrence with 28,000 hp. installed 1911-15, the Montreal Island Power Company at St. Vincent de Paul on Des Prairies river with 45,000 hp. installed 1929-30 and the great Beauharnois plant of the Beauharnois Light, Heat and Power Company on the St. Lawrence with a present capacity of 400,000 hp. installed 1932-35.

In the territory along the north shore of the St. Lawrence from Montreal to Murray Bay and south of the St. Lawrence from the St. Francis river easterly to Riviere du Loup, power development and distribution are largely in the hands of the Shawinigan Water and Power Company and its subsidiaries. The company's first development at Shawinigan Falls on the St. Maurice commenced delivery of power from an installation of 20,000 hp. in 1902; transmission to Montreal followed in 1903. Installations at Shawinigan Falls have been systematically increased until at the present time they aggregate 278,500 hp. In 1928 the 176,000-hp. plant of the Laurentide Power Company at Grand'Mere was acquired and enlarged in 1931 to 188,500 hp. The La Gabelle plant was brought into operation in 1925 with 120,000 hp. and enlarged in 1931 to 152,000 hp. Finally Rapide Blanc, the fourth development on the St. Maurice, was brought into operation in 1934 with an installed capacity of 160,000 hp. The company also owns or controls a 22,200-hp. plant on the Batiscan river completed in 1926, two on the Montmorency and one each on the Jacques Cartier, Chaudiere, Ste. Anne de Beaupre, du Sud and La Fourche rivers with an aggregate installation of 43,750 hp.

To the south of the St. Lawrence a considerable area lying between the Richelieu and St. Francis rivers is served by the Southern Canada Power Company incorporated in 1913. Of the company's seven hydroelectric stations aggregating 60,780 hp., the two largest are on the St. Francis river at Drummondville with 19,500 hp. and at Hemming Falls with 33,600 hp.

In the Saguenay-Lake St. John district the first development took place on the Au Sable river at Jonquiere in 1906 and by 1923 nearly 85,000 hp. had been developed in the region chiefly for the manufacture of pulp and paper. Then followed the great development on the

Fig. 17—St. Margaret Bay, N.S. Tidewater Plant, N.S. Power Comm. Installed 1922 with 6,900 hp.

Fig. 18—Musquash Development of N.B. Electric Power Comm. Completed 1922. 11,100 hp.

Saguenay. In 1925 the Duke-Price Power Company (now the Saguenay Power Company) brought its plant at Isle Maligne into operation with 360,000 hp., later to be enlarged to 495,000 hp. and in the period 1931-1934 the Alcoa Power Company completed a development of 260,000 hp. at Chute-à-Caron. This power supplies pulp and paper mills in the district, the reduction works of the Aluminum Company of Canada at Arvida and a considerable portion is transmitted to Quebec where it supplements the supply of the Shawinigan Water and Power Company.

On the Metis river to the south of the St. Lawrence the Lower St. Lawrence Power Company has a plant of 9,600 hp. brought into operation in 1923 and enlarged in 1930. The company serves a territory extending from Trois Pistoles to Matane and down the Matapedia valley to Matapedia.

In the Ottawa valley and in the territory immediately west and north of Montreal, power supply is mainly in the hands of the Gatineau Power Company. The company was incorporated in 1925 and, in addition to acquiring a number of developments already in operation, immediately commenced construction of three large developments on the Gatineau river at Chelsea, Farmers and Paugan Falls. These were brought into operation in 1927-28 and later enlarged to an aggregate capacity of 470,000 hp. Two stations on the Ottawa river in Hull were acquired with installations totalling 36,600 hp., one on the same river near Bryson which has a present capacity of 51,400 hp. and another on Gordon creek at Temiskaming where 24,000 hp. is developed. In addition to these there are ten small plants on the Rouge, Blanche, North and other rivers which tie into the system furnishing power to most of the towns and villages of the lower Ottawa valley. The company's principal customers are the Canadian International Paper Company with large mills at Gatineau, Temiskaming and Hawkesbury and the Hydro-Electric Power Commission of Ontario.

In the same territory the MacLaren-Quebec Power Company has two large plants on the Lievre river, 120,000 hp. at High Falls and 136,000 hp. at Masson installed in 1930 and 1933 respectively. These plants furnish power to pulp and paper mills at Buckingham and Masson and to the Hydro-Electric Power Commission of Ontario. The Commission also receives the entire output of the 112,000-hp. plant of the Ottawa Valley Power Company at Chats Falls on the Ottawa river installed in 1931-32.

The mining district in the north-western part of the province is served by the Canada Northern Power Corporation from a plant on the Quinze river with 40,000 hp. installed in 1923 and 1928.

The largest municipally owned enterprise in the province is that of the city of Sherbrooke with five plants on the St. Francis and Magog rivers totalling 18,050 hp. These installations were progressively made from 1888 to 1929.

A very material contribution to hydro-electric development and the conservation of water-power resources in the province of Quebec has been made by the Quebec Streams Commission by its policy of promoting the creation of storage reservoirs for the purpose, mainly, of increasing the minimum flow of power rivers in the interest of primary power production. The Commission's reservoirs in the St. Maurice watershed have practically trebled the minimum flow in the power reach of the river and similar benefits have accrued on the Gatineau, Lievre, St. Francis, Ste. Anne de Beaupre, Metis and other rivers where reservoirs have been created.

### Prince Edward Island

The water-power resources of Prince Edward Island are not large, the rivers are small and water-power develop-

Fig. 19—Queenston Development, Niagara River, H.E.P.C. of Ont. In Operation 1922. Capacity now 560,000 hp.

Fig. 20—La Gabelle, St. Maurice River, Que. S.W. and P. Co. Installed 1924. Present Capacity 152,000 hp.

Fig. 21—Isle Maligne, Saguenay River, Que. Installed 1925 by Duke-Price Power Co. Capacity now 495,000 hp.

Fig. 22—Chelsea and Farmers, Gatineau River, Que. In Operation 1927. Capacity now 232,000 hp. Gatineau Power Co.

ment is mainly used for the operation of local mills. Eight hydro-electric plants have been built but only one of these, serving Montague, Georgetown and Cardigan, has an installation in excess of one hundred horse-power, the two stations on the Montague river having a combined capacity of 245 hp. The total water-power installation in the province is 2,439 hp., having increased to this figure from a total of about 1,500 hp. in 1900.

New Brunswick

Early water-power development in New Brunswick was chiefly in connection with local industries. In 1900 there was a total installation of 4,600 hp.; by 1910 this had grown to 11,200 hp., in 1920 to 22,000 hp., in 1930 to 133,700 hp. and remained the same at the end of 1936.

One of the earliest hydro-electric developments was that of the Maine and New Brunswick Electrical Power Company on the Aroostook river. The first installation of 1,500 hp. was made in 1906 and additions and alterations were made until it reached its present capacity of 11,400 hp. in 1925. The plant is near the international boundary and power is distributed in Canada and the United States.

The largest development in the province is that of the Gatineau Power Company at Grand Falls on the St. John river with an installation of 80,000 hp. The plant was brought into operation in 1928 and units were added in 1929 and 1931. Power is sold chiefly to paper mills at Edmundston and Dalhousie.

In 1918 the New Brunswick Electric Power Commission was created and since that time has taken a major part in the distribution of electrical energy in the more populous parts of the province. A hydro-electric development of 11,100 hp. was completed on the Musquash river in 1922 and a fuel-power station constructed at Grand Lake in 1931 has now a capacity of 16,330 hp. To supplement its supply, the Commission purchases power from private sources.

Among other hydro-electric developments in New Brunswick, the Bathurst Company has a 14,500-hp. plant on the Nipisiguit river, the municipality of Edmundston one of 1,475 hp. on Green river, the Fraser Companies 2,060 hp. on the Madawaska river, the St. George Pulp and Paper Company 4,134 hp. on the Magaguadavic river and Canadian Cottons Limited 3,500 hp. at Milltown on the St. Croix river.

Nova Scotia

Many small powers were utilized in the pioneer days in Nova Scotia and by 1900 there was a total installed capacity of 19,800 hp. In 1910 this had increased to 31,500 hp., to 37,600 hp. in 1920, to 114,200 hp. in 1930 and 120,700 hp. at the end of 1936.

It is apparent from these figures that most of the growth has taken place since 1920. This has been due chiefly to the activities of the Nova Scotia Power Commission, a public ownership enterprise established in 1919. The Commission's first developments at St. Margaret Bay came into operation in 1922 with 10,820 hp. and was enlarged in 1927 to 15,820 hp., the power being sold in Halifax. Developments followed on East River Sheet Harbour in 1924-25 totalling 11,840 hp., power going to Pictou county and a local paper mill. Three stations were constructed on the Mersey river in 1929 and two others were later acquired and reconstructed, giving a total present capacity of more than 32,000 hp. These installations are primarily to supply a paper mill at Brooklyn but furnish power as well to Liverpool and the surrounding district. A plant of 3,000 hp. on the Tusket

Fig. 23—South Slocan, Kootenay River, B.C. Completed 1928, with 75,000 hp. West Kootenay Light and Power Co.

river near Yarmouth was completed in 1929 and other smaller plants have been built or acquired in other parts of the province. The Commission at present generates about 56 per cent of the electrical energy produced in Nova Scotia.

Next to the Commission, the Nova Scotia Light and Power Company has the most extensive development. Ten hydro and two fuel plants supply its system which extends from Halifax to Windsor and west to Lawrencetown. The White Rock station on Gaspereau river of 1,105 hp. was installed in 1919, the Hemlock Falls station on the Avon river, 2,500 hp. in 1924; the Falls River station, 4,350 hp. in 1928 and the Black River station, 4,500 hp. in 1930. Smaller plants are maintained on the Nictaux, Falls, Bear, Currell, Philip and East rivers and fuel stations at Halifax and Barrington.

Yukon

In the Yukon Territory, the Yukon Consolidated Gold Corporation operates a hydro-electric development near the North Fork of the Klondyke river. The plant was installed in 1911 with 10,000 hp. and enlarged in 1935 to 15,000 hp. Power is supplied to the city of Dawson and for the operation of the gold dredges of the company.

Fig. 24—Grand Falls, St. John River, N.B. In Operation 1928. Capacity now 80,000 hp. Gatineau Power Co.

## GROWTH BY BASIC INDUSTRIES

It is of interest also to make brief reference to the growth of the use of hydro-electric power in certain of the basic industries of Canada during the fifty-year period. It is furthermore indicative of the general interdependence of basic industry and low-priced power. Detailed statistics are not available for the earlier years. Sufficient are available, however, to present a picture of the relationship of hydro power to the industrial growth of the Dominion.

### Central Electric Station Industry

By the end of 1890, three years after the beginning of the fifty-year period, the central electric station industry had achieved a total hydro-installation of only 1,165 hp. This did not represent quite the entire utilization of water power for electric distribution, as in the earliest stages of the industry there was some purchase of hydraulic power from lumber and other mills for the operation of electric generators by central stations. As of the same date, 10,967 hp. were installed in pulp and paper mills and 59,383 hp. or 83 per cent of the total installation, in saw, grist and grinding mills and miscellaneous industrial plants. Probably a very small proportion of the hydraulic installation of the pulp and paper mills and general industrial group was used for electric generation.

At the present time there is a complete reversal in position. Now, 88 per cent of the total installation is developed for central electric station use, and a large proportion of the pulp and paper and other purpose installation also drives electric generators to provide electricity for plant lighting and operation.

In the central electric station industry the capital invested has grown from $401,942,402 in 1918 to $1,459-821,168 in 1935. A consideration of the growth of the industry by five-year periods from 1890 to date, discloses the revolutionary effect upon hydraulic development resulting from the application of electricity to public use. As already stated, the central electric station installation at the end of 1890 was 1,165 hp. or only 16 per cent of the total installation. In the following five-year period, 1890-1895, 39 per cent of all new development was for central station purposes, this proportion increasing to 64 per cent for the second period, 1895-1900, and to 70 per cent for the next period, 1900-1905, before the end of which the central station installation exceeded the combined installation for all other purposes. The proportion rose steadily until, for the last complete period, 1930-35, 97 per cent of all new installation was for central station use. For the year 1936 an even higher ratio obtains.

The production of electricity is now considered a very significant barometer of commercial and industrial conditions. This is illustrated in Fig, 6, the lowest line showing the growth of production of kilowatt hours from hydro central-electric stations during the period 1920-1936. Depressed business conditions in 1921 caused a small decrease in production that year while the pronounced decrease in 1931 and 1932 reflected the much more serious condition brought about by the depression commencing in 1930. The diagram indicates the very substantial increase in production that has taken place in the past sixteen years.

### The Pulp and Paper Industry

The pulp and paper industry increased its newsprint production from 350,000 tons in 1913 to 3,190,599 tons in 1936, a more than ninefold growth. Successive increases in installation are recorded in each of the five-year periods up to the end of 1915 when a peak in growth of direct power installation was reached, apparently largely due to a new policy of organizing an affiliated

Fig. 25—Ghost Development, Bow River, Alta. Installed 1929 with 36,000 hp. Calgary Power Co.

Table II
Fuel Central-Electric Stations in Canada
Main Plant Equipment

| Year | Steam reciprocating engines hp. | Steam turbines hp. | Gas and oil engines hp. | Total hp. |
|---|---|---|---|---|
| 1918 | 54,784 | 90,853 | 13,286 | 158,923 |
| 1919 | 53,068 | 102,865 | 14,221 | 170,154 |
| 1920 | 49,430 | 80,750 | 12,714 | 142,894 |
| 1921 | 45,450 | 90,705 | 15,345 | 151,500 |
| 1922 | 40,484 | 89,545 | 16,080 | 146,109 |
| 1923 | 37,116 | 87,767 | 16,415 | 141,298 |
| 1924 | 33,876 | 90,617 | 17,000 | 141,493 |
| 1925 | 34,230 | 101,457 | 17,822 | 153,509 |
| 1926 | 36,386 | 103,847 | 19,705 | 159,938 |
| 1927 | 33,788 | 144,683 | 19,866 | 198,337 |
| 1928 | 29,206 | 131,295 | 21,635 | 182,136 |
| 1929 | 26,103 | 156,873 | 23,652 | 206,628 |
| 1930 | 22,861 | 207,364 | 26,774 | 256,999 |
| 1931 | 18,590 | 238,929 | 26,929 | 284,448 |
| 1932 | 13,940 | 266,679 | 26,776 | 307,395 |
| 1933 | 12,375 | 270,523 | 27,111 | 310,009 |
| 1934 | 12,560 | 253,745 | 27,182 | 293,487 |
| 1935 | 11,810 | 257,525 | 26,838 | 296,173 |

Table III
Fuel Central-Electric Stations in Canada
Auxiliary Plant Equipment

| Year | Steam reciprocating engines hp. | Steam turbines hp. | Gas and oil engines hp. | Total hp. |
|---|---|---|---|---|
| 1918 | 20,595 | 96,000 | 603 | 117,198 |
| 1919 | 15,060 | 102,500 | 223 | 117,783 |
| 1920 | 12,771 | 123,600 | 221 | 136,592 |
| 1921 | 13,436 | 119,600 | 526 | 133,562 |
| 1922 | 20,476 | 129,110 | 671 | 150,257 |
| 1923 | 19,686 | 129,110 | 776 | 149,572 |
| 1924 | 22,911 | 143,950 | 1,241 | 168,102 |
| 1925 | 23,389 | 147,415 | 2,366 | 173,170 |
| 1926 | 22,529 | 151,615 | 2,721 | 176,865 |
| 1927 | 13,338 | 128,965 | 2,744 | 145,047 |
| 1928 | 13,828 | 141,982 | 3,423 | 159,233 |
| 1929 | 15,866 | 148,799 | 7,223 | 171,888 |
| 1930 | 14,966 | 148,799 | 7,688 | 171,453 |
| 1931 | 16,048 | 160,171 | 7,824 | 184,043 |
| 1932 | 18,184 | 157,871 | 8,824 | 184,879 |
| 1933 | 19,984 | 164,571 | 9,014 | 193,569 |
| 1934 | 19,384 | 178,453 | 9,594 | 207,431 |
| 1935 | 19,309 | 178,453 | 9,069 | 206,831 |

central station company in conjunction with its parent pulp and paper company and in many cases of buying part or all of the power required from existing central stations. Since 1915, while there has been a falling off in new direct power development, there has been steady growth in power demand by the industry, resulting in the development to date of more than 600,000 hp. by the industry itself and the purchase of more than 55 per

**Fig. 27—Island Falls, Churchill River, Sask. Installed 1930. Capacity 42,000 hp. Churchill River Power Co.**

cent of all power sold by central stations for industrial purposes. The total hydro power used in the pulp and paper industry at the present time is in the neighbourhood of 1,635,000 hp.

### The Mineral Industries

The mineral industries have increased in value of product from $10,221,000 in 1889 to $361,394,000 in 1936. The general availability of low-cost hydro energy in ready accessibility to mining centres has been a prime factor in the development of the industry to its present high position in the industrial fabric of the Dominion. Low-cost hydro power has made possible the exploitation of Canada's low grade ore deposits, thus adding immeasurably to the national wealth. While a considerable installation has been placed by the mining industry for direct operation in the course of its development during the past fifty years, here again the practice of forming a power company in conjunction with the mining company and of purchasing power for operation, has been followed. At the present time more than 1,000,000 hp. of hydraulic power is used by the mineral industries.

The foregoing brief comment is indicative of the manner in which the growth in the use of hydro-electric power has kept pace with the growth of the basic industries of the Dominion. It is safe to say the low cost of hydro-

**Fig. 26—Upper Lake Falls, Mersey River, N.S. One of Three Plants Installed 1929 by N.S. Power Comm. Combined Capacity 29,300 hp.**

**Fig. 28—High Falls, Lievre River, Que. In Operation 1930, Capacity now 120,000 hp. McLaren-Quebec Power Co.**

electric energy has been largely instrumental in making possible the remarkable growth of these basic industries.

### Fuel-Electric Power

A review of fifty years of hydro-electric development in Canada would not be complete without some eference to the situation with respect to fuel-electric power development in the same period.

While more than 98 per cent of the electrical energy generated in Canada is from water power nevertheless fuel power plays an important part in certain sections of the country, particularly in the Maritime Provinces and in Alberta and Saskatchewan where native fuels are readily available.

It is not possible to trace the growth of fuel power as applied to the generation of electricity throughout the past fifty years, as reliable statistics only date from the year 1918, following the inception of the annual census of the central electric station industry. However, it is known that many of the early electric generating installations were supplied by fuel power, as they could be quickly installed in the communities to be served and could be readily enlarged to keep pace with the modest growths in load that took place in these early years. With the development of high tension transmission these pioneer fuel stations were largely superseded. This change marked the early growth of the industry in Ontario and Quebec where no native fuels existed and where an abundance of favourably situated water powers stimulated the development and transmission of hydro-electric power and has been a more recent development in Manitoba and Alberta following the development of three very extensive transmission systems.

**Fig. 30—Chute-à-Caron, Saguenay River, Que. In Operation 1931. Present Capacity 260,000 hp. Alcoa Power Co.**

**Fig. 29—Chats Falls, Ottawa River, Ont. Jointly Owned by H.E.P.C. of Ont. and Ottawa Valley Power Co. Operated in 1931. Capacity now 224,000 hp.**

While much of the replacement of fuel stations by hydro power had taken place before 1918, when reliable statistics first became available, certain replacements continued to be made in the subsequent years and had an appreciable effect on the progress of fuel power development from year to year. Table II shows the installed fuel-power capacity in main plant equipment for the years 1918 to 1935 inclusive while Table III indicates the installed fuel-power capacity in equipment auxiliary to hydro-electric stations. The installation in both tables has been classified under the headings: steam reciprocating engines, steam turbines and gas and oil engines.

It is seen that during the period 1918-1935 an increase of 87 per cent took place in main plant equipment in fuel central electric stations while in auxiliary plant equipment the increase was 77 per cent. The figures indicate a gradual reduction in the total installed capacity of steam reciprocating engines and a steadily increasing growth in the capacity of steam turbines and gas and oil engines.

In regard to the average capacity of generating units the 1935 figures indicate in main plant equipment 4,292 hp. for steam turbines, 220 hp. for steam reciprocating engines and 82 hp. for gas and oil engines while in auxiliary plant equipment the corresponding average figures are 3,432, 439 and 178 hp. respectively. These figures illustrate that steam turbines are being utilized where loads of considerable magnitude are encountered. Gas and oil engines are meeting the smaller demands and steam reciprocating engines are falling into disuse.

Among fuel-electric stations generating primary power the outstanding installations are found in Nova Scotia, New Brunswick, Saskatchewan and Alberta.

In Nova Scotia the Seaboard Power Corporation which operates the power plants of the Dominion Steel and Coal Corporation has a 38,760-hp. steam turbine installation in the Sydney - Glace Bay area, the Acadia Coal Company 9,000 hp. in steam turbines at Stellarton, and the Canada Electric Company 19,000 hp. in steam turbines at Amherst.

In New Brunswick the New Brunswick Electric Power Commission has a steam turbine station at Grand Lake with 16,330 hp. installed which delivers power to its transmission line network serving the southern part of the province. The New Brunswick Power Company has a 13,700-hp. steam turbine and a 2,900-hp. reciprocating engine installation in Saint John while the Canadian International Paper Company (New Brunswick) has a 16,750-kw. steam turbine installation at Dalhousie to supplement its hydro supply from Grand Falls.

In Saskatchewan the National Light and Power Company has a 31,265-hp. steam turbine installation at Moose Jaw, the Saskatchewan Power Commission a 27,033-hp. steam turbine installation at Saskatoon, a 3,900-hp. steam turbine and 950-hp. reciprocating engine installation at North Battleford and 6,050-hp. in various internal

Fig. 31—Beauharnois, St. Lawrence River, Que. In Operation 1932. Present Capacity 400,000 hp. Beauharnois Light Heat and Power Co.

Fig. 32—Canyon, Abitibi River, Ont. In Operation 1933. Capacity now 330,000 hp. H.E.P.C. of Ont.

combustion engine plants throughout the province. The city of Regina has a 46,619-hp. steam turbine installation, Canadian Utilities 4,000-hp. in steam turbines at Prince Albert and 4,679-hp. in various internal combustion engine plants. The Dominion Electric Power has 3,780-kva. steam turbo installation at Estevan and 4,360-hp. in internal combustion engines at various stations.

In Alberta the city of Edmonton has an installation of 1,560 hp. in steam engines and 31,100 hp. in steam turbines, the city of Medicine Hat 8,350 hp. in steam turbines, the city of Lethbridge 750 hp. in reciprocating engines and 7,300 hp. in steam turbines and Canadian Utilities 5,300 hp. in steam turbines at Drumheller.

In addition to the fuel stations referred to above, a number of the hydro-electric distributors maintain auxiliary fuel power stations for emergency use. While there is also some use of this equipment during periods of peak demand, its auxiliary nature is indicated by its unit output being only about one per cent of that of the main plant fuel equipment. The largest auxiliary station is the 29,500-hp. Hamilton, Ontario, station acquired by the Hydro-Electric Power Commission of Ontario in its purchase of the Dominion Power and Transmission Company. The British Columbia Power Corporation has a 24,200-hp. steam turbine plant in Vancouver and a 6,000-hp. plant at Victoria. Montreal Light, Heat and Power Consolidated has a 22,000-hp. station at Montreal and the municipality of Winnipeg one of 14,740-hp., the Winnipeg Electric Company maintaining a similar standby of 12,000-hp.

The Calgary Power Company operates two auxiliary plants in Calgary, one of 14,650-hp. and one of 4,500-hp. and a number of smaller stations at various points throughout its transmission area. At Sentinel, Alberta, the East Kootenay Power Company has a steam turbine plant of 13,334 hp. to supplement the output of its Elko and Bull River, British Columbia, hydro plants. The city of Westmount has 10,724-hp. steam turbine equipment in connection with its refuse disposal plant to supplement power purchased from Montreal Light, Heat and Power Consolidated for distribution.

The Associated Gas and Electric Company has a 8,500-hp. station in Halifax, Nova Scotia, and the Moncton Electric Company a 3,600-hp. station in Moncton, New Brunswick.

### Conclusion

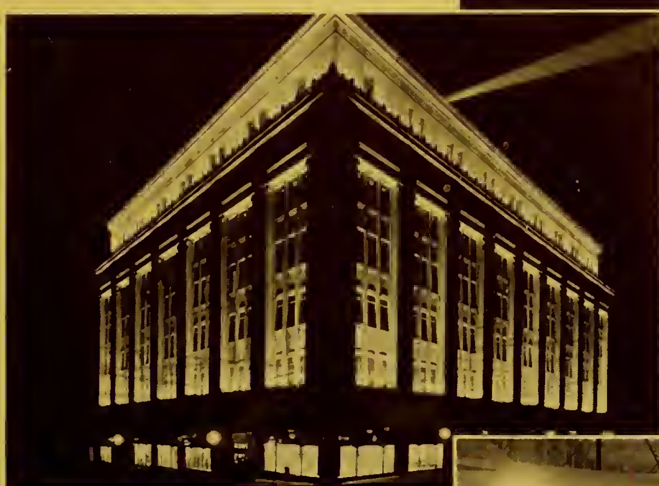
In conclusion, it may be said that the extraordinary development of power in Canada during the past fifty years, as briefly reviewed in this paper, has profoundly altered conditions throughout the Dominion. In this relatively short period, indeed, electric energy has so revolutionized our manner of living and has enabled us to develop our natural resources to such an extent that Canada today is scarcely recognizable as the country it was fifty years ago. The development and distribution of this power has brought to more than sixty per cent of our population the boon of electricity for light and for the many conveniences and labour-saving devices which so greatly ameliorate our living conditions today. It has penetrated extensively into our rural districts bringing to farm dwellers the conveniences and comforts already enjoyed by our urban population. It furnishes the low-cost energy so necessary for our basic industries and has enabled Canadian products to attain a prominent place in world export markets. It has brought entirely new communities into being. It has resulted in the direct

Fig. 33—Rapide Blanc, St. Maurice River, Que. In Operation 1934. Installed Capacity 160,000 hp. S.W. and P. Co.

expenditure of more than $1,600,000,000 of capital in power plant and distribution facilities. It has, in fact, been a tremendous factor in our entire national development influencing the growth of our population, our transportation systems, our home markets, our external trade and our national income. Who, fifty years ago, could have foreseen that the crude dynamos of the day would father the vast progeny of machines and facilities we are now using. Who, today, would venture to predict what another half century will bring forth. Canada, however, with her great undeveloped reserves of power is strategically situated to hold and to improve her position in the march of world progress.

MOBILE COLOUR LIGHTING

STREET LIGHTING



FLOOD LIGHTING

INDUSTRIAL LIGHTING

DEVELOPMENT OF ILLUMINATION

DURING THE past few years rapid advancement has been made in illumination. These illustrations show four important applications of modern lighting practice.

*Illustrations through the Courtesy of the*
CANADIAN GENERAL ELECTRIC CO. LIMITED

# Industrial and Manufacturing Development

*Fraser S. Keith, B.Sc., M.E.I.C.,*
*Manager, Department of Development, The Shawinigan Water and Power Company, Montreal.*

*"Canada, in a very special way, may be considered the child of modern engineering. The growth of land, sea and air transport during the last half century, and, above all, the use of hydro-electric power in recent years, have made it possible to build from the scattered colonies of British North America one of the foremost industrial nations of the world."*

*(Vincent Massey, high commissioner for Canada in Great Britain, 1936.)*

*"There could be no better instance of engineering as a factor in nation or empire-building."*

*(Sir Alexander Gibb, President, Institution of Civil Engineers—November 1936.)*

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Industry in Canada's early days was mothered by necessity and fathered by courageous initiative, and throughout has been fostered by nature, increasingly bountiful. During the fifty years under review the engineer—electrical, mechanical, mining, chemical—must be credited with a contribution that has been a determining factor in manufacturing progress.

The field has been lavish and above all else in value, the sea supplied generously, the mine a rapidly expanding contributor, but the forest has been the stand-by of industry in Canada. The fur trade was its offspring. The earlier settler was enabled to endure adverse conditions because of its beneficence. Shipbuilding, a once leading activity, found in the forest its sturdy materials, the important lumber and wood-using concerns a ready source of supply. The water that furnishes power to its great consumer, the pulp and paper industry, is conserved in its shade. To many manufacturers the forest provides the major raw material and no industry is independent of it.

### IN 1887[1]

Canada was in a period of depression. The gay and prosperous Nineties were not anticipated. Queen Victoria celebrated the fiftieth year of her reign. The Marquess of Lansdowne was Governor-General. John A. MacDonald was returned to power confirming the national policy for the protection of industry. The total revenue of the Dominion was thirty-five million nine hundred thousand dollars. The seven provinces of the Dominion had an income of twelve million nine hundred thousand dollars. The gross value of manufactured products was around four hundred million dollars in 75,000 establishments. During the year 84,526 settlers arrived in Canada, bringing goods valued at nearly four million dollars, Manitoba receiving half the number. Montreal had a population of 200,000, Toronto 66,000, Winnipeg 22,000, and in Vancouver, which had been reduced to ashes the year before, the citizens, numbering about 2,000, were living mostly in shacks and tents. The steam engine and small water powers turned the wheels of industry. Pride of craftsmanship prevailed. The apprenticeship system was universal. The first sulphite paper-making mill in Canada was installed at Merritton in the Niagara Peninsula.[2] The electric light had made its appearance on the streets of Montreal the previous year and was a novelty. There were 13,950 telephones in use in all Canada. The year saw the first C.P.R. transcontinental train from Montreal to Vancouver, and cotton cloth shipped to the Orient. The horse furnished the motive power for the street cars in Montreal, Ottawa and Toronto. The Street Railway Company of Montreal built that year a new stable to accommodate four hundred horses. The winter carnival with its ice palace was an outstanding social event. The tallow candle had all but disappeared and homes throughout the country, except those few contiguous to a gas main, were illuminated by the coal oil lamp. Canning was done at home. The coal oil lantern was in common use. The livery stable flourished and the horse and buggy or cutter were highway transportation de luxe. Highways were not surfaced and sidewalks were of wood. The high-wheeled bicycle, the forerunner of the pneumatic tired safety, was a proud vehicle for both touring and racing. Many men wore whiskers; their favourite head-gear was a bowler hat. The business and professional man wore a boiled shirt and a black string tie. While the crinoline had gone to the attic, red flannels had not been entirely discarded, and the well-dressed woman wore a bustle. The business woman had not arrived. Manual labour earned less than one dollar a day. Wages were paid in cash. Eggs were fourteen cents a dozen, butter was seventeen and one-half cents, and cheese nine and one-half cents a pound. Whisky was five cents a glass. A letter press was standard office equipment. Correspondence was by hand, the typewriter a new-comer. Hydro-electric power was unknown. There was no wireless telegraphy or telephony; no gramophones, kodaks, motion pictures, automobiles, radios, television, aeroplanes, submarines; no adding machines, cash registers, mechanical accounting or teletype; no gas engines, no roller bearings, individual machine drives, high speed steel, arc welding, acid resisting alloys or synthetic resins; no cellophane, no rayon. There were no electric household appliances, no electric refrigerators, vacuum cleaners, toasters, ironers, hot water heaters; no air conditioning, no oil burners, no robots, no electrical eyes. Rugged individualism flourished. Sixty hours was the minimum week's work.

### INDUSTRIAL SEQUENCE SINCE CONFEDERATION[3]

This country has seen twelve eras or industrial cycles since Confederation. The first of five years after the birth of the Dominion was prosperous. There followed seven lean years from 1873 to 1879. Expansion was a trend until '84, when another depression set in, lasting five years. The seven years following '89 saw prosperity return, and for the seventeen years from '96 there was a golden period in manufacturing, which even the brief depression, 1907-08, did not halt. In 1913 many great projects were completed. Since that year conditions have been abnormal. In 1914 industry saw inactivity. The war boom lasted five years, until 1919; then, nearly four years of retrogression. The six years, 1923 to 1929, brought the great boom; the next four years—the great depression. The twelfth era is with us and industry accelerates rapidly.

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[1]Canada Year Book, 1887; Montreal Gazette, 1887; General Dictionary of Canada (Reverend F. LeJeune); The Canadian Manufacturer; Montreal Bureau of Statistics (Conrad Archambault); Castle Hopkins' Encyclopaedia of Canada; Bell Telephone Company; Canada Illustrated, 1887; Montreal Star.

[2]The first sulphate paper mill on the continent commenced operations ten years later at Windsor Mills, P.Q.

[3]Canada and its Provinces, General Economic History, Volume 9; The Monetary Times; Canadian Manufacturer; The Canada Year Books; Census of Industry, General Manufacturer's Branch, Dominion Bureau of Statistics; Industrial Canada; Montreal Gazette; "The Manuacture of Munitions in Canada"—Presidential Address, H. H. Vaughan, M.E.I.C., 1919—In this paper the story of how Canadian enterprise, inspired and directed by engineers, made industrial history, is well told.

The first five years in Canada's history after Confederation brought national prosperity, in which the manufacturer shared as he did in the seven lean years that followed. Farm products held first place. The depression following 1873 affected most industries with foreign markets —the lumber trade, textiles, hardware, furniture and the boot and shoe industry. Flour mills, distilleries and breweries used local supplies. Cheese factories made rapid growth. The pork packing industry was transferred from the farm to the factory. Manufacturers of grey cottons increased four-fold in the ten years following Confederation and drove out competition. Dye houses were introduced and checks and coloured shirtings made. The McKay sewing process in place of wooden-pegging methods transformed the boot and shoe industry. Canada ranked fifth among the nations in registered shipping, and in proportion to population, in shipbuilding and navigation Nova Scotia led the world.

* * *

The next five years up to 1884 saw a period of expansion in which the national policy was given credit for bringing the depression to a close in 1879. Good harvests in Canada coincided with the worst in Great Britain during the century. The country enjoyed the expansion brought about by railway construction. The West was having a boom. The investment in favoured industries added stimulus. The milling industry was being transformed by the adoption of the roller mill process. Binder twine and cordage pools formed in Quebec and Maritimes.

* * *

The years 1884 to 1889 were again years of depression. A period of foreign trade expansion ended in 1882 and commenced again in 1892. The national policy did not prove a panacea. A small and stagnant market faced the manufacturer. The prices of farm produce decreased. Foreign trade fell below the mark of 1873. There was bitter discord—religious, racial, political.[4] A strong agitation for commercial union with the United States became a major controversy. Relations with our southern neighbour were not happy—disputes over transportation, fisheries, the tariff.

* * *

The year 1889 saw the beginning of prosperity. The increase in the production of leather goods, cotton, agricultural implements, musical instruments, liquors, woodpulp, and household effects was notable. The McKinley tariff in 1890 brought the country closer to Great Britain and increased British trade in 1895-96 to sixty-two million dollars compared with thirty-four millions purchased by the United States. Over-production capacity for cotton and agricultural implement manufacturing brought about consolidations. A Canadian's experiments produced calcium carbide in 1892.

* * *

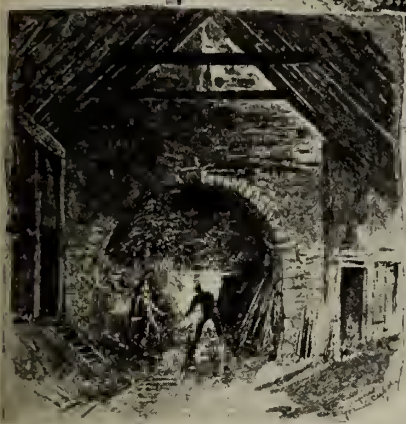
An era of progress, hitherto unexperienced in the Dominion, commenced its upward swing in 1896 and continued until 1912. Factories employing five hands or over increased production from three hundred and sixty-eight million dollars in 1890 to four hundred and eighty-one million in 1900. This, ten years later, had expanded to one billion one hundred and sixty-five million. Many new subsidiary industries were established. Combinations in industry increased. Labour unions increased in power, employers' associations were organized. Transportation facilities improved. Electricity revolutionized production. Capital amounting to one and one-half billion dollars was invested, largely by Great Britain. Population increased nearly two million from 1901 to 1911. New customs tariffs were introduced in 1907—British, intermediate and general. Industries founded on farm products continued to have the greatest value. Milling increased rapidly, capital investment in the first decade from fourteen to forty-three millions, output value thirty-one to eighty-two millions. Industries based on other products of the farm, cheese and butter-making, canning and preserving and meat-packing, expanded, but were unable to supply markets due to the diversion of raw materials. Notable advances were made in manufactures of leather goods. Domestic tobacco came into greater use, and cigar and cigarette making advanced more rapidly than smoking and chewing tobacco. Cotton manufacturing thrived. The cloth-making branch of the woollen industry declined, owing to British woollen competition, made possible by the preferential tariff of 1897. Production in hosiery and knitting factories trebled between 1900 and 1910, and the making of carpets, blankets and flannels expanded. Tailoring to order was largely superseded by factory-made clothing. The demand for timber increased and prices soared. Regulations by the provinces requiring sawing of timber cut on crown lands, and that forest products be manufactured to the most advanced stages, hastened the union of water-power and forest wealth —two major factors in Canada's tremendous production during this century. There were seven millions invested in the pulp and paper industry in 1900, and over twenty millions five years later. Thirty thousand tons of steel and fifty thousand tons of pig iron grew in production from 1896 till 1911 to eight hundred and seventy-six thousand tons of the former and nine hundred and seventeen thousand tons of the latter. Those who dreamed of the self-sustaining iron and steel industry in Canada in 1887 did not realize their ambitions. Canadian ores were not produced in sufficient quantities to meet furnace needs. Water powers of the St. Maurice made possible the production of aluminum, and together with those of Niagara, produced calcium carbide and carborundum on a large scale. Oil refining came under the control of outside oil interests. The explosive industry prospered due to railroad construction and mining. The oil paint and varnish business benefited from manufacturing and building activity. The early years of the century brought prosperity to the agricultural implement industry. The home market was for the most part held by Canadian companies, who exported in some cases up to fifty per cent of their output to Australia, South America and Europe, in spite of the keen competition of the United States. By the adoption of modern improvements, manufacturers of machinery and tools—a pioneering industry in the country—continued their success. The output of electrical apparatus, valued at two million dollars at the beginning of the century, advanced to fifteen million dollars in ten years. Outstanding in its significance and in its influence on industry in Canada, the manufacture of motor-cars was initiated in this period, commencing as assembly plants, subsidiaries of United States automobile companies. Plants for the production of rolling stock for railways were unable to supply the demand. A proposal to renew the Reciprocity Treaty of 1854 to 1864 with the United States was defeated by popular vote in 1911.

* * *

The short depression of 1907 and 1908 inaugurated an orgy of mergers which saw some forty-one industrial combinations formed,[5] absorbing one hundred and ninety-six separate firms or companies. The products affected by these amalgamations were steel and coal, cement, asbestos, rolling mills, steel and screw works, railway rolling stock, breweries, canneries, rubber goods, knit goods, foundries,

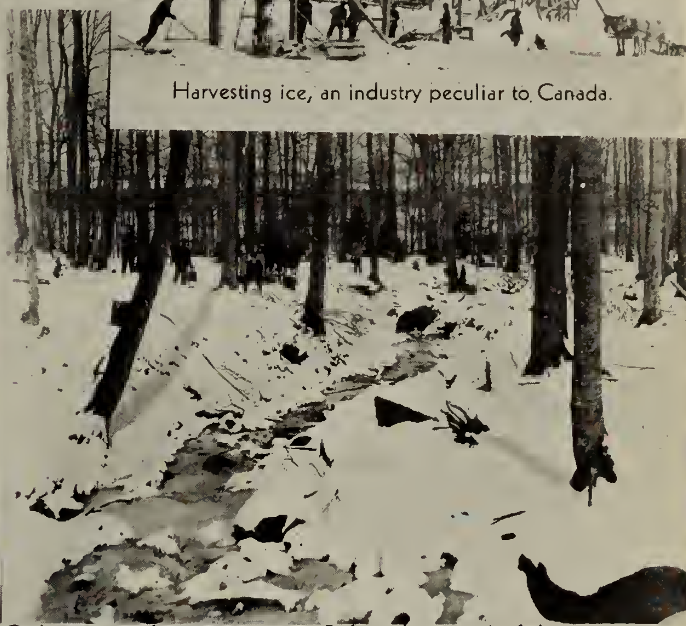
[4]"The mephitic vapours that emanate from 'Globe' editorials when advocating annexation are more nauseating than any that are diffused in the atmosphere by any polecat that ever offended the olfactory organs of mankind." (Editorial Comment, The Canadian Manufacturer, January 3, 1890).

[5]Compilation of Monetary Times.

The Old Forges of the St. Maurice, Quebec. Here in 1733 during the French regime the first metal-working industry on the continent was established and continued for 150 years.

Harvesting ice, an industry peculiar to Canada.



Gathering sap for maple sugar. Before the arrival of the white man the Indians made sugar and syrup from the sap of the hard maple. Today sugar and syrup are the products of 50,000 farms.

Shipbuilding at Lunenburg, N.S. Canada's wooden clippers were world famous. In 1878 the Dominion of Canada possessed over 1,300,000 tons registered shipping. No better vessels sailed the seas.

The old mill with its overshot water-wheel around which the villages of early days sprang up.

French-Canadian peasant, 101 years old, at her spinning-wheel.

Typical salmon cannery on Fraser River near New Westminster, B.C. The salmon fishery of British Columbia gives to that province first place with respect to value of production.

In the earlier days in French Canada almost every house possessed a spinning-wheel and hand loom, providing clothing and all the fabrics needed for the home. The Ursuline nuns taught spinning and weaving. These home industries still exist.

**Industries of Earlier Days.**

spinning and cotton, packing, paint, coal and coke, milling, boot and shoe, and to a lesser degree bread, milk, ice, fish, lumber, explosives, felts, soaps, jewellery, carriages, silk, thread, and wood-working machinery. Navigation companies and railroads joined the procession, power companies followed, and in the merging of banks this movement reached its summit. While the majority of these mergers were subjected to the criticism of being over-capitalized and of providing unwarranted profits to promoters, it would appear that many of these did justify their existence, for industry in strong hands was enabled to take advantage of the opportunities offered by the requirements of the Great War, the record of which presents an epic in industrial history.

* * *

With the collapse of the land boom in the West in 1912, the completion of railroad construction in 1914, with few new enterprises contemplated, depression faced Canada's apparently over-expanded industrial establishments—and 1914 was a depression year.

* * *

The war years and after proved to be most momentous in Canada's industrial history. The enormous production of war munitions is attributed alike to the co-operation of manufacturers and the genius of the Canadian engineer. The Shell Committee, responsible for initial production, was largely a body of engineers. The Imperial Munitions Board, formed later, carried on. One thousand members or twenty per cent of the Canadian Society of Civil Engineers went to the front. Feverish activity featured the metal-working industry. Many new plants were built. Industry, which absorbed many women, worked at high pressure, in many instances twenty-four hours a day, three hundred and sixty-five days a year. Manufacturers of machine tools were unable to supply the demand. Of munitions alone, Canada produced in all forty-seven million shell cases and in the year 1917 fifty-five per cent of the 18-pounder shrapnel, forty-two per cent of the 4.5-inch, twenty-seven per cent of the 6-inch, twenty per cent of the 60-pounder, fifteen per cent of the 8-inch and sixteen per cent of the 9.2-inch shells obtained by the British Government. The value of Canadian manufactured goods rose rapidly until 1920.

* * *

The first three years of the Twenties were reactionary, production dropping from a peak of over three and three-quarter billion dollars in 1920 to two and one-half billion dollars in 1922. The number of establishments decreased but slightly. Wages decreased over twenty per cent. Significant was the introduction in 1921 of the electric boiler, invented by a Canadian.

* * *

Well-equipped and efficiently organized from the prosperity of war years, the country's industrial establishments were ready and able to take advantage of the enormous demand required to replenish war depleted world markets. Her great supply of raw materials—mineral, agricultural and forest products—combined with low-priced power, brought Canada rapidly forward as an exporting nation. The years 1923 to 1929 saw unprecedented metal production, mining output increasing from a value of approximately one hundred and seventy-five millions to well over three hundred millions. During this period Canada became temporarily a capital exporting country, over one and one-quarter billion dollars having come into the country during the war. The huge investment of United States capital from 1914 to 1920 was now increasing the nation's output. Successive large harvests at relatively high prices were a foundation of prosperity. A boom greater than those of the war years continued until 1929, when production rose to a peak of four billion dollars in spite of the forty-one per cent reduction in the price of manufactured goods — an all-time record.

* * *

What might be rightly called the great depression, lasted from 1929 to 1933, during which latter year, due to lessened production and lower values, the total amounted to slightly more than half of that of the year of greatest output.

The present era, which commenced four years ago, referred to later in this article, is of the same order as that of the middle and late Twenties.

## THE ENGINEERS' CONTRIBUTION TO INDUSTRY[6]

The contribution of the engineering profession to the expansion of industry during the past fifty years is not only outstanding but revolutionary.

### Mechanical

In the machine tool realm the engine lathe had already been provided with a quick change gear box, more accurate feed and threading stops. At the beginning of this period, the turret lathe was just coming into use. Soon the power and rigidity of the machine were increased. Tool posts with curved blocks allowed tools to be adjusted vertically. Compound rests were introduced. In the first decade of this century high speed steel revolutionized the lathe as it did all production machine tools. The mechanical engineers have made continuous progress. During this period the individual motor drive was introduced, which together with geared heads became common during the next decade, and the forest of belts thinned out. Antifriction spindle bearings and pneumatic chucking were the next improvement. The automatic screw machine invented in the 70's continued as such for twenty years, when it became more highly developed and capable of turning out quantities of articles much more complicated than simple screws. The capacity, the speed and the accuracy, as well as the capabilities of these automatics were increased year by year. A vertical turret lathe was introduced, lending speed and convenience to heavy chucking work. Boring mills carried on a single bed and grouped about a massive central standard, with a ring of revolving chucks indexing around the tool slide, marked a further advance. Individual drive has become almost universal, and the screaming of belts has disappeared. Reversing motors have been adopted along the lines of those used in rolling mills. Planers and shapers have improved comparably with the lathe. Their work has been supplanted for production purposes by the milling machine. The universal milling machine with hydraulic feed occupies a prominent place in the production line. Jigs, fixtures and gauges have developed with the machine tool and have gained constantly in accuracy.

The production of munitions during the war and the requirements of the automotive industry have created a major revolution in metal production. The advent of tungsten carbide relegated all existing machine tools to obsolescence. Heavier machines requiring great power were built to obtain the benefit of this cutting material. Great power projects with exceptionally large units demanded machine tools of extreme size and accuracy. Special mention of the copying type die sinking machines is made, for without these the forming dies for metal tops, mudguards and streamlined body parts of automobiles would be cut only at great cost and at an extremely low rate of production. To utilize these dies, tremendous presses, some as much as forty feet in height, were designed to press and draw the material.

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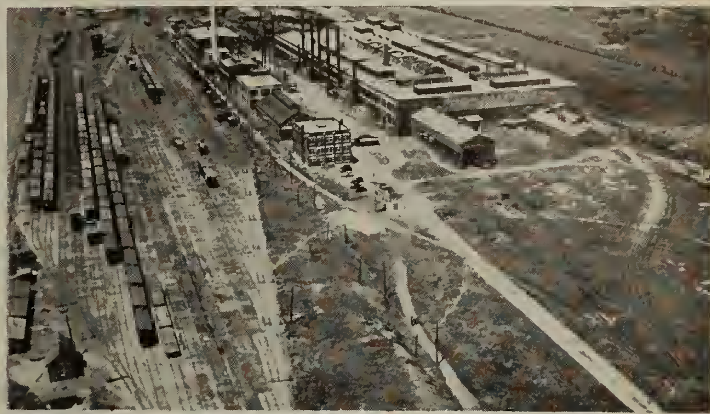
[6]Mechanical Engineering, Journal of the American Society of Mechanical Engineers, Fiftieth Anniversary Issue—April, 1930; Engineering News, 1887; Engineering (London), 1887; Engineering (London), 1936; Canadian Electrical News, 1893, Canadian Machinery.

Canadian Vickers Limited owns and operates a floating dry dock and shipbuilding yard at Montreal, and produces industrial and mining machinery, structural steel, aircraft and kindred products. Plant covers 28 acres and employs 450 hands.

Canadian Car & Foundry Company, Ltd.—Longue Pointe plant, Montreal. Part of the steel foundry division of The Canadian Car & Foundry Company. Capacity over 30,000 tons of finished steel castings per annum, used in the manufacture of freight and passenger cars in other of the company's seven plants located at Montreal, Fort William, Brantford and Welland.

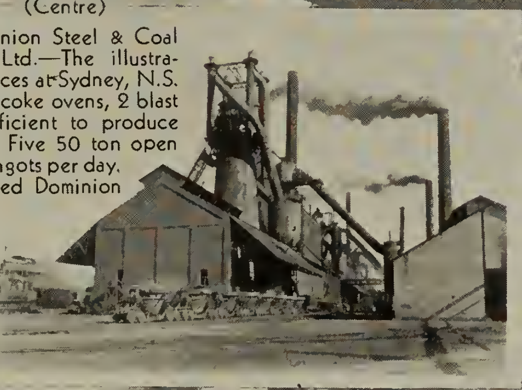


View of the Canadian Ingersoll-Rand Company, Ltd. works at Sherbrooke, Que., as they exist in 1937, and as seen from the Sherbrooke-Montreal highway. This picture shows the extensive buildings which cover an area of over 30 acres, including foundry, pattern shops, machine shops and other buildings. (Below)

Jenkins Brothers, Ltd.—This is the first unit, opened officially on April 6, 1932, in an extensive development program on a 500,000 square foot site at Lachine. The photograph shows the modern bronze and iron foundry building and power house, where valves and goods are manufactured principally for export. (Below)

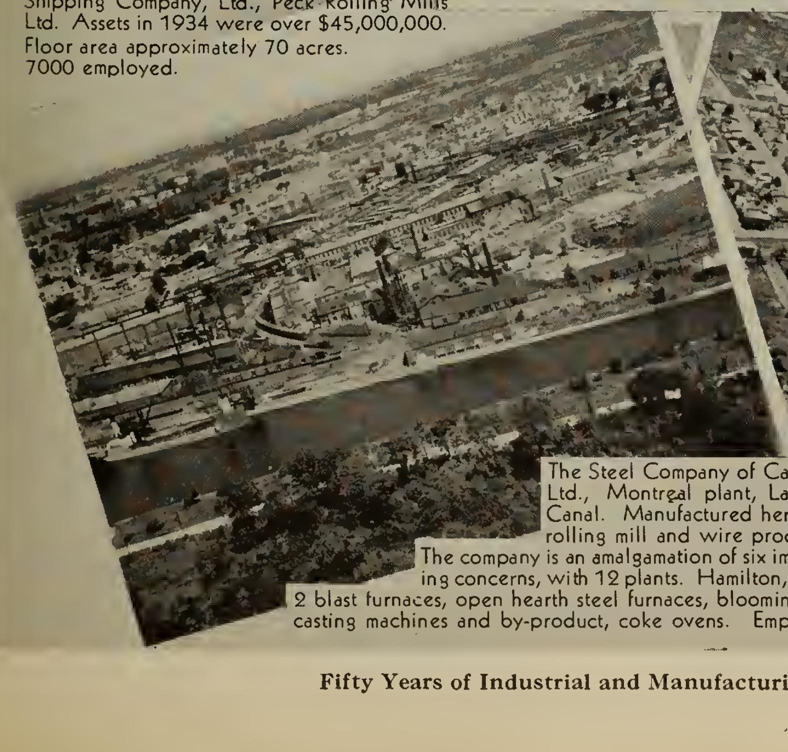
(Centre)

Dominion Steel & Coal Corporation, Ltd.—The illustration shows blast furnaces at Sydney, N.S. This plant comprises 150 coke ovens, 2 blast furnaces and equipment sufficient to produce 300 tons of pig iron per day. Five 50 ton open hearth furnaces in addition produce 600 tons ingots per day. The company, incorporated in 1928, acquired Dominion Iron & Steel Company, Ltd., Dominion Steel Corporation, Ltd., and British Empire Steel Corporation, Ltd., and control of Cumberland Railway & Coal Co., Halifax Shipyards Ltd., Nova Scotia Steel & Coal Company, Ltd., Eastern Car Company, Ltd., Dominion Coal Company, Ltd., Sydney Lumber Company, Ltd., James Pender & Company, Ltd., Dominion Shipping Company, Ltd., Peck Rolling Mills Ltd. Assets in 1934 were over $45,000,000. Floor area approximately 70 acres. 7000 employed.



(Below)

Dominion Bridge Company, Ltd.—View of works and head office at Lachine, Que. Here are fabricated bridges, structural steel work, and electric and hand power travelling cranes. Dominion Engineering Works, seen in the background, manufacture paper mill machinery, turbines and special equipment. The company built in 1929 a fabricating shop in Calgary and a plant in Vancouver. About 1500 people are employed in ten plants.



The Steel Company of Canada, Ltd., Montreal plant, Lachine Canal. Manufactured here are rolling mill and wire products. The company is an amalgamation of six important metal working concerns, with 12 plants. Hamilton, Ont., plants include 2 blast furnaces, open hearth steel furnaces, blooming, billing and rod mills, rolling mills, pig casting machines and by-product, coke ovens. Employs over 4,000. (Left)

Fifty Years of Industrial and Manufacturing Development in Canada.

In the field of quantity production the automobile has imposed on the engineer the task of constructing single purpose machines, such as cylinder block milling machines, cylinder boring machines, tappers and reamers, crankshaft turning machines, multiple drills and many others, which will do only one job. Hence the change in design of any part has meant the scrapping of existing special equipment or heavy alteration charges.

The process of broaching has been elevated to a very important degree. Centreless grinding has come into great prominence in the last three or four years, and with straight or formed faced wheels cylindrical work is produced at rates of speed and limits of accuracy undreamed of by the old method of turning and grinding. Wrist pins, front and rear axles and spring rods are examples of work done by centreless grinding.

In view of the extreme precision to which multiple production is now held, standard micrometer and "go and no-go gauges" are entirely too slow and variable for accurate results. A system of electrical gauges is in use in many instances which measures diameter, length and weight. The readings are entirely visual, these scales being calibrated much the same as on a voltmeter. In many cases these gauges are magazine fed and the operators, frequently girls, have only to watch the scales. Some are automatic and defective parts are knocked out of production when they fail to measure up to required limits.

The use of alloy steel has aided designers in producing articles, strong and light. It is reported that there are approximately 500 different alloys in use in the automobile industry. The use of steel has been greatly influenced by autogenous welding which has come into general use during the last quarter century. Electric and oxy-acetylene welding of steel has reduced fabrication costs by superseding riveting and other mechanical methods of joining metals, so that fabricated parts often replace iron castings. Oxy-acetylene cutting has practically eliminated mechanical methods of severing steel plate of all thicknesses, cutting off risers, and removing defects in billets.

High specifications of quality and accuracy are now firmly entrenched in all engineering work. The mechanical engineer in the motor industry has pioneered these standards. As a result, engineers in all branches of industry are producing work of the highest quality at moderate costs in this time of large power units, high speed transportation equipment, and general engineering, with great endurance and a maximum of safety.

### Power in Industry

The water wheel was the prime mover for the flour and grist mills around which the earliest towns and villages in Canada grew, but for a considerable period, including most of the first decade of this century, the steam engine played an important role. Its use is now largely confined to districts remote from hydro-electric energy or to industries requiring steam for processing. In 1887 most factories used steam engines, the power being transmitted by shafting and belting, gearing or rope drives. Small plants were equipped with simple non-condensing engines, while large mills experimented with compound-condensing. The efficiency of mills increased where exhaust steam could be used in process work. The smaller manufacturer depended upon the slide-valve engine controlled by throttling governor. Working pressures of between 60 and 75 lb. per square inch were common and over one hundred pounds exceptional. About 1900 some of the larger engines developed an indicated horse-power hour with from 15 to 16 lb. of steam at a gauge pressure of 140 lb.

The high speed automatic cut-off engine was developed to operate electric generators. Edison bi-polar dynamos required speeds of 800 to 1,200 rev. per min. The construction of multiple generators with greater capacities and decreased speed was the solution of direct-connected engine drive. These engines were the horizontal single cylinder automatic cut-off type. A vertical single acting type with a closed crank case was produced. Single and compound engines of this category were extensively used in the early Nineties.

The years between 1890 and 1900 saw a vast improvement in the high speed steam engine. Steam pressures rose from 70 to 175 lb. Early forms of steam turbines made their appearance in 1896, but did not prove adaptable to industrial work. Keen interest was shown in superheated steam. Improvements made in water tube boiler construction and under-feed stokers were favourably received. The use of cheaper grades of fuels and anthracite screenings was made possible. Vacuum returns came into vogue. Between 1900 and 1910 high speed turbines were introduced. Steam pressures up to 200 lb. were used and temperatures of between 500 and 550 deg. prevailed. The introduction of pulverized coal necessitated redesigning furnaces. Between 1910 and 1920 smaller turbines, geared, were direct connected and supplanted high speed turbines for many purposes. Fuel oil appeared in competition with coal and treatment of feed water was studied. During the past seventeen years great strides have been made in the design of boilers and stoking equipment. Pressures of between 450 and 600 lb. became common with temperatures as high as 700 to 750 deg.

Designed to use by-products of the manufacture of kerosene, the forerunner of the present gasoline engine appeared in the 80's, and weighed about 1,000 lb. per horse-power up to a three horse-power capacity The present day cost of a three horse-power engine is about $60; in 1887 it was about $2,000. Refinement of the internal combustion engine commenced at the turn of the century. It has revolutionized transportation and, combined with electricity, powers the automobile, and has made possible the science of aviation.

The first Diesel engine appeared in the United States in 1898. In Canada it is used to a considerable extent to supply the motive power for the mining industry, and in districts where hydro-electric power is not available. Since 1930 refinements of this type of engine have been so great, coupled with its much lower cost of operation, that it now looms as a competitor of the gasoline engine for heavy highway transportation.

### Electrical

During the decade preceding 1887, the commercial application of electricity in the industrial field had received considerable impetus and alternating current transmission and distribution by means of transformers had been accomplished on a commercial but limited scale.

The fundamental conception of the magnetic circuits in rotating equipment was not yet clearly understood, and the years following produced marked changes in the physical construction of generators and motors. The alternating current generator of that period was of the rotating armature type with open or face wound coils, and the construction of slotted armatures providing greater mechanical and electrical security for the windings, was a development of the early nineties. The design of modern rotating field generators was evolved from the early hydro-electric installation at Niagara Falls which utilized this form of construction, excepting that the field coils rotated on the outside of the armature and were supported from the shaft by an umbrella-like structure.

Before the end of the 19th century the generating equipment had assumed much of its present form. Later developments have been toward larger capacities with refinement in the materials, and higher speeds with the

The Canadian Marconi Company, Montreal, erected this handsome new plant in the Town of Mount Royal, Que., in 1930. Equipment embodies complete facilities for the manufacture of radio receivers, transmitters and specialty apparatus, which includes direction finding equipment, audiphones and public address systems. This year ground was broken for a considerable addition to this factory.

Montmorency plant, Montmorency Falls, Que., of Dominion Textile Company, Ltd., an amalgamation of many cotton mills, which, with those of its subsidiaries, are equipped with approximately 600,000 spinning spindles, 38,700 twisting spindles and 11,380 looms, giving employment to about 8,000 operatives.

Interior of first glass walled factory building in Canada, completed in 1937 as a 4-storey and basement addition, 63 ft. by 220 ft., to the Imperial Tobacco Company of Canada, Ltd.'s extensive factory system. The building is of reinforced concrete, the walls on 3 floors glass brick, 2 in. thick, 12 in. by 12 in. Cost of building is 3 cts. per cu. ft. more than if steel sash were used. Advantages claimed are high insulating qualities, contribution to humidity control, light giving properties, and beauty. (Above)

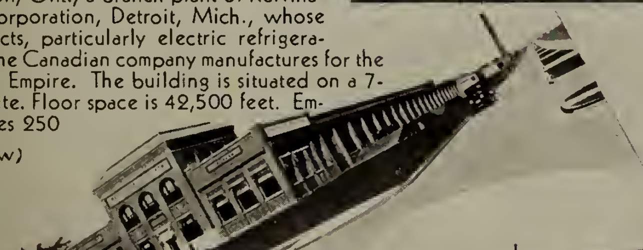
Canadian Industries Limited. On this site at Shawinigan Falls, Que., are located three distinct "C.I.L." plants manufacturing cellophane, hydrogen peroxide and trichlorethylene, the latter a cleaning fluid. The "Cellophane" plant occupies the bulk of the picture with the hydrogen peroxide unit visible in the extreme background at the left. These plants have been continuously expanded since the first cellophane machine was installed in 1932, and now employ over 250 persons.

Western Clock Company, Ltd., Peterborough, Ont., a branch plant of a United States concern, established there during the depression following the war boom, to manufacture trade marked clocks and timepieces. Employee comfort and safety have been given special consideration. (Above)

(Left)

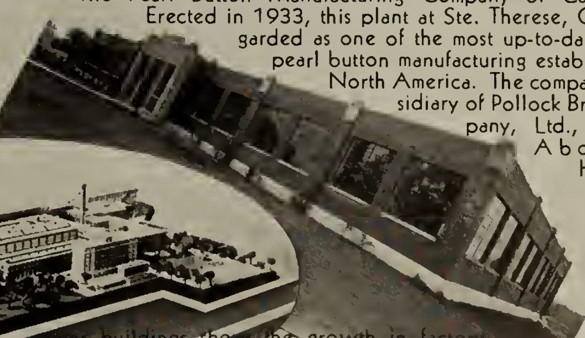
Collins & Aikman Canada, Ltd., Farnham, Que. This substantial plant, 400 ft. by 250 ft., houses an industry engaged in the manufacture of velours and plushes. This establishment has led to the production in Canada of yarns not previously spun in this country, while the industry itself makes certain fabrics hitherto imported. Approximate employment 100 people.

Modern plant of A. Wander Limited, Peterborough, Ont., in which a patented vegetable product is made.



New plant of Kelvinator of Canada, Ltd., London, Ont., a branch plant of Kelvinator Corporation, Detroit, Mich., whose products, particularly electric refrigerators, the Canadian company manufactures for the British Empire. The building is situated on a 7-acre site. Floor space is 42,500 feet. Employees 250

(Below)



The Pearl Button Manufacturing Company of Canada, Ltd. Erected in 1933, this plant at Ste. Therese, Que., is regarded as one of the most up-to-date specialty pearl button manufacturing establishments in North America. The company is a subsidiary of Pollock Bros. & Company, Ltd., Montreal. About 100 hands are employed.

Expansion of electrical industry in Canada is illustrated by the plaster model of the Canadian Westinghouse Company, Ltd. plant at Hamilton, Ont., the original buildings of which are centered around the chimney at the right. The other buildings show the growth in factory operation, in the manufacture of electrical machinery, equipment and apparatus, that has taken place in this important Canadian industry since it was incorporated in 1903.

**Fifty Years of Industrial and Manufacturing Development in Canada.**

advent of the steam turbine. The first alternating generators were of the single phase type and were utilized for supplying current for lighting. The single phase induction motor followed rapidly and enabled the alternating supply of current to be used for motive purposes as well. It was not until the development of the polyphase motor in the early nineties, that much progress was made in the application of electricity to industrial requirements for motive power. Since that date electrical engineers have designed and constructed motors to meet every conceivable requirement of industry in regard to capacity, speed and performance. From the minute motor driving the hands of a synchronous clock to the largest motors on rolling mills and hoists, the engineer has contrived to find a running mate for every job.

The first alternating current generators were built without much regard to the frequency of alternations. The design of the machines supplied by each manufacturer was based on considerations of safe speed of operation and physical construction with the number of poles or magnetic circuits which would lend themselves to convenient manufacture. Consequently, a wide variety of frequencies existed, which in themselves, created no particular hardship since interconnections between generating plants were not required. With the advent of the polyphase motor and the rotary converter for supplying direct current to railway systems a standardization of frequency was inevitable. After much controversy as to the most suitable frequency, opinion crystallized on 60 cycles as most desirable for motive purposes and lighting, and 25 cycles for electro-chemical, long distance transmission and conversion to direct current. Technical developments and improvements in the art have practically eliminated the advantages which were considered inherent to 25-cycle frequency, with the result that 60 cycles is the predominant frequency of today.

For the benefit of industry, as well as the large number of domestic consumers, power companies now maintain a precision control of the frequency. Speed variation in motive equipment, which is so important to the textile, paper and other industries, is now reduced to negligible proportions, and such momentary changes now rarely exceed three-tenths of one per cent of the synchronous speed.

One of the earliest applications of electric motive power was for traction purposes in the operation of street railways by direct current. The growth of alternating current power systems, however, and the improvements in flexibility and control of the induction motor have led to some use of alternating current for heavy traction on railroads. The development of the mercury arc rectifier with its increased efficiency and lower operating costs, has given new life to direct current systems for heavy traction purposes. The mercury arc rectifier with the refinement of grid control, is also coming into increasing favour with the heavy industries using direct current for electro-chemical processes.

The thermal conversion of surplus power from hydro-electric developments by the electric steam boiler has been undertaken in Canada during the past ten years on a very large scale. Steam is produced by electro-thermal process in the plants of industries requiring large amounts of process steam, thus enabling both the manufacturer and the supply company to benefit by the arrangement.

The industries have not been slow in recognizing the speed and accuracy of electric control devices. Practically every industry finds use for one or several of the refinements for automatically timing, regulating or controlling some operation in manufacture.

### INDUSTRY IN 1891[7]

The table of industrial statistics, 1891, lists 75,741 establishments in Canada, with an invested capital of $345,526,259, employing 370,104 hands, distributing to wage-earners $100,656,502 a year, and producing articles valued at $476,183,356. Ontario with 32,150 plants leads Quebec with its 23,011 by a considerable margin. The other provinces follow in order:—Nova Scotia 10,496, New Brunswick 5,429, P.E. Island 2,679, Manitoba 1,031, British Columbia 770, Territories 375. Of the total employed, 273,327 were male over sixteen years of age and 70,156 female. Boys employed numbered 19,556 and girls 7,065. Average yearly earnings including all classes were for the year 1891, $272.

An explanation of some of the industries enumerated in Table I is given because the classifications differ entirely from those of 1935. The item "foods—vegetable" includes 2,550 flour and grist mills, with an output of $52,423,000, and 1,656 bakeries. Confectionery was also included. The animal food industry is represented chiefly by 4,627 fish curing and 1,565 cheese factories. Sawmills, numbering 5,666, with an invested capital of over $50,000,000, employing over 50,000 people and an output of over $50,000,000 led the list in "matters—vegetable," and were followed by carpentering with 4,618 factories. Of cooperages there were 1,524 establishments, and shingle mills, planing and moulding factories, and pump and wind mills were the most important of the balance. Brush and broom making was the principal item in "matters—animal," which includes soap and candles, glue factories, and tallow refineries. Aerated waters, brewers and maltsters, cider making and cigar factories accounted for 626 of the total 769 plants in "drinks and stimulants." Wine making, coffee and spice mills, distilleries, sugar refineries, and cocoa and chocolate making were other items. Cabinet and furniture factories led in "furniture and houses and buildings," followed by lime kilns, and sash, door and blind factories had the greatest volume of output. Paints and varnish, plaster, mattress making, cement mills, and roofing materials were also included. The 621 foundries and machine shops, with an output of $16,400,000, were the foremost industry in "machines, tools and implements," while 1,500 tinsmith shops, employing 3,800 people, produced $4,793,000 worth of products. This classification also included tin and sheet working, iron and brass fittings, edge tools, locksmithing,

Table I

Industrial Statistics—1891

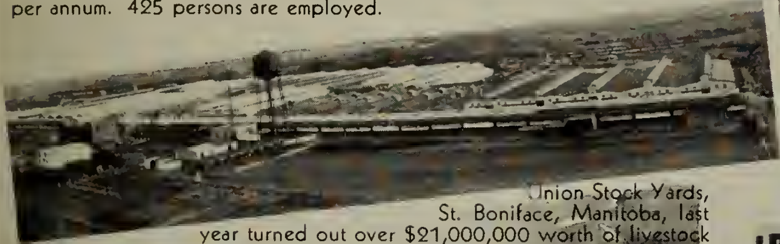
| Industry | No. of establishments | Capital $ | No. of employees | Wages $ | Value of output $ |
|---|---|---|---|---|---|
| Arms and ammunition | 54 | 1,107,011 | 495 | 175,394 | 1,105,205 |
| Books and stationery | 723 | 10,540,431 | 9,906 | 3,875,553 | 10,553,487 |
| Carriages, etc | 3,384 | 10,918,285 | 14,462 | 5,369,946 | 19,711,581 |
| Chemicals | 733 | 4,138,157 | 2,895 | 981,628 | 5,505,419 |
| Drinks and stimulants | 769 | 27,430,074 | 10,938 | 3,642,212 | 33,729,826 |
| Fibrous material | 248 | 3,235,325 | 2,961 | 627,352 | 3,448,971 |
| Foods—vegetable | 4,638 | 31,442,768 | 16,573 | 5,009,553 | 69,806,988 |
| Foods—animal | 7,280 | 11,339,570 | 34,622 | 3,406,339 | 25,864,305 |
| Furniture, houses and Buildings | 3,738 | 18,212,155 | 19,183 | 6,514,756 | 25,009,361 |
| Gold and silver | 691 | 2,987,131 | 1,923 | 780.332 | 3,090,501 |
| Leather, boots and shoes | 7,773 | 18,891,585 | 25,699 | 7,574,770 | 35,193,982 |
| Lighting | 225 | 21,324,214 | 3,892 | 1,293,165 | 7,475,821 |
| Machines, tools and implements | 12,641 | 55,684,129 | 49,422 | 17,815,445 | 62,016,178 |
| Matters—animal | 256 | 1,630,737 | 1,516 | 524,836 | 3,379,381 |
| Matters—vegetable | 14,745 | 78,386,050 | 83,226 | 21,374,061 | 84,548,742 |
| Mathematical instruments, etc | 18 | 47,555 | 52 | 19,410 | 74,975 |
| Musical instruments | 92 | 2,389,633 | 2,204 | 973,223 | 3,393,213 |
| Ships and boats | 669 | 2,555,951 | 4,145 | 1,213,122 | 3,712,462 |
| Stone, clay and glass | 1,314 | 8,362,255 | 12,406 | 3,580,620 | 10,221,207 |
| Textile fabrics and dress | 15,458 | 43,056,149 | 71,847 | 15,547,726 | 67,172,034 |
| Miscellaneous | 487 | 938,204 | 1,498 | 348,433 | 1,169,117 |

[7]Nearest date to 1887 for which complete statistics are available.

Head office and works of The John Bertram & Sons Company, Ltd., at Dundas, Ont. Manufactured in this large plant are the Pratt & Whitney line of machine tools, as well as mine hoists, winders, presses and rock drills. The approximate output of the plant is $1,000,000 per annum. 425 persons are employed.

Ogilvie Flour Mills Company, Ltd., operate plants at Fort William, Winnipeg, Medicine Hat, Edmonton, Montreal. The plant at Medicine Hat, Alberta, is illustrated. In these mills are manufactured flour, feed, rolled oats, wheathearts and other cereals, cattle and

poultry feeds, of which are exported flour, feed and rolled oats. Approximate value of output of the company is $12,000,000 giving employment to 1,750 people.



Union Stock Yards, St. Boniface, Manitoba, last year turned out over $21,000,000 worth of livestock products in this 52 acre plant. Approximately 300 persons are employed. The tremendous floor area of the plant is clearly visible in the photograph.

Campbell Soup Company, Ltd., New Toronto, Ont. This modern plant started operations during 1931, occupying over 110,000 square feet of floor space for the packing of soups, pork and beans, spaghetti and tomato juice. About 150 operatives are employed.

Typical of modern trends in construction is this recently completed new streamlined plant of Duplate (Windsor) Limited at Windsor, Ont., where safety glass will be produced.

Plant of the Canadian Sugar Refineries, Ltd., at Raymond, Alberta. The production of sugar beet is centered in south-western Ontario and near Raymond, Alberta. Refined beetroot sugar amounting to 119,857,668 lbs., valued at $4,617,733, was produced in 1935.

American Can Company's handsome plant at Simcoe, Ont. Completed in the spring of 1930, this plant manufactures cans of all kinds. The building is constructed of concrete and steel, and provides over 110,000 square feet of floor area, in addition to warehouse capacity of 100,000 square feet.

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furnaces, stoves and heaters, engine building, rolling mills, iron and steel bridges, and type foundries.

### NUMBER OF MANUFACTURING ESTABLISHMENTS

The striking decrease in the number of manufacturing establishments from over 75,000 in 1891 to approximately 25,491 in 1935, is evidence of the elimination of many of the small local industries which flourished in every town and village fifty years ago, the majority of which supplied local needs.

Mergers, consolidations, increased factory production and the growth of individual manufacturing units in the larger centres, made it impossible for most of these small industries to exist, although some did grow and prosper to a point of securing markets from coast to coast, and doing an export business as well.

### EMPLOYMENT IN MANUFACTURING

The manufacturing industries of Canada employed in 1887 some 335,000 people. The curve of employment in manufacturing shows a steady and consistent advance from the year 1870 to 1910. In those years there was no unemployment in Canada. The decade from 1900 to 1910 saw an increase in industrial employment of over 45 per cent. Economic depressions exerted little or no influence on the continued increase. The years 1910 to 1920, the decade in which the gross value of manufactured products rose to hitherto unknown peaks, found the number of employees the same at the end as at the beginning, with a slight increase up to 1917. Then came reaction. During the first of the depression years 1921, over 150,000 of the 620,000 workers, or more than 25 per cent of all gainfully employed in industry were idle. From this time until 1929, with a slight dip in 1923 and 1924, employment increased at the most rapid rate in the history of Canada, reaching the peak of nearly 700,000 in 1929. The collapse from that date to 1932 to 1933 was as precipitous as the previous increase. Since then, however, employment is increasing at the same rate as that of 1924 to 1929. The curve does not indicate the industrial boom of the war years, because mechanical equipment promoting mass production had become an increasingly greater factor in output. The depression following the Great War is clearly indicated, the boom of the twenties, the greatest depression in Canada's history from 1929 to the early thirties, with its attendant lowered production, unemployment, the dole, and general industrial upheaval. The trend of the curve at present, if continued during the next few years, would indicate that industry will again absorb many unemployed.

### SALARIES AND WAGES

From 1870 to 1880 the total annual wages and salaries paid to Canadian workers increased very slowly. From the year 1880 to 1900 increase was more pronounced. From 1900 to 1916 there was a rapid acceleration in the amount paid and the industrial boom years of the war saw an increase greater than the total increase of the previous forty-five years. The depression from 1920 to 1922 is strikingly illustrated in a decrease from $733,000,000 to slightly over $500,000,000. Increased production was shown from 1922 with a slight dip in 1924 up to the peak production in 1929, when wages were approximately $815,000,000. From that year to 1933 the decrease was rapid, but since then the amount of wages has been going rapidly forward until in 1935 we see it approximating that of 1918, but far below the peaks of 1919 and 1928. Salaries and wages for 1935 were $590,300,000.

The average employee in industry receives four times as much as his grandfather earned fifty years ago.

### BRANCH PLANTS IN CANADA

The establishment of manufacturing plants in Canada by companies already existing in other countries had commenced when the present century began, and the number and variety of these concerns, coupled with the value of their output, have had a noteworthy influence in bringing this country to its position as an exporter of manufactured goods. No other nation has had such an experience.

The major influences in this movement were the tariff policy, the requirements imposed by patent laws, and the desire to take advantage of the valuable trading position of the country, due to raw materials, favoured nation treaties with numerous non-Empire countries, and Empire trade agreements. While the contribution from Great Britain has been of no small importance, the proximity of the parent plants in the United States, together with the reasons already cited, accounts for the great majority of these industries in the Dominion.

The importance of the branch plant as a factor in Canada's impressive industrial growth since 1900 may be appreciated when it is realized that from the year 1900 to 1934, capital invested in branch plants amounted to well over two billions of dollars, compared with a total investment in all industries in the same period of approximately four and one quarter billions of dollars.

The curve of branch plant growth in Canada, plotted from 1900 to 1935, graphically shows the progress in such plant establishment. The period from 1900, at which time there were 132 branch plants in Canada, to 1918 is one of almost uniform location of new industries. Following the war, however, a great acceleration took place, which extended until 1932, when there were 1,852 branches of foreign firms in the Dominion. Since then there has been a lessened increase. Latest returns for the current year, however, lead to the conclusion that the branch plant will continue to play a progressive part in Canada's path to further industrial diversification.

### COST OF ELECTRICITY IN INDUSTRY

Electricity's quickening impulse to industry is largely due, in the industrial portions of Canada at least, to its availability in any amount, the flexibility of its service, and its low cost. In an estimate made[8] of the cost of electricity in relation to the value of the output, covering thirty-seven industries, in only four of these does that cost exceed two per cent. Pulp and paper heads the list with 9.76 per cent, acids, alkalies and salts 7.45 per cent, compressed gases 3.53 per cent, and electrical apparatus and supplies 2.03 per cent. Of the industries where the cost exceeds one per cent and is less than two, there are eight. Of the remaining twenty-five the cost ranges from 0.97 per cent for woollen textiles to cotton and jute bags 0.18 per cent.

### ORGANIZED LABOUR

The Dominion Trades and Labour Congress, established in 1873, is the head of the internationally organized workers in Canada, and represents them in legislative matters. The National Catholic Union dates from 1901, when it came into existence in Quebec City. Other national Catholic unions were formed in the province of Quebec, and these were co-ordinated in 1921 by the Confederation of Catholic Workers in Canada. In 1927 the All-Canadian Congress of Labour was organized at a meeting of national representatives held in Montreal. There were in the Dominion in 1935, 1,794 international locals with 143,570 members and 934 non-international unions with a membership of 437,134. Labour is forty-eight per cent unionized.

At the present time there is a war between rival factions of the American Federation of Labour, which has caused serious industrial unrest in the United States. An attempt was made by one faction, the Committee for

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[8]The Dominion Bureau of Statistics, Mining Metallurgical and Chemical Branch, March 30, 1937.

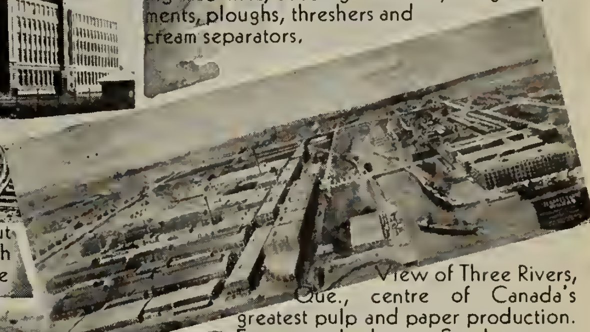
The largest sawmills in Canada are located on the Pacific coast of British Columbia, where the heaviest stands of large timber exist. The mills of the Powell River Company at Powell River, B.C. are shown. Of 2,578,000,000 feet board measure of lumber cut in Canada in 1934, British Columbia produced 1,464,000,000, of which Douglas fir was over 1,000,000,000.

The Goodyear Tire & Rubber Company of Canada, Ltd., has three factories, the one illustrated is at New Toronto. Floor area is 17 acres. Products are automobile, truck, bus, tractor, and motor cycle tires and tubes, also repair materials. Export all lines. Salesvalue of output of this plant is in excess of $1,000,000 per month. Employees March, 1937 were 1,300.

Rayon plant of Courtaulds Limited, located at Cornwall, Ont., manufactures rayon yarns, none of which is exported. The floor area of the plant is 260,000 square feet, the number of employees 2,000, and the approximate value of output $6,000,000 per annum. The growth of this plant in 10 years is a romance in Canadian industry.

Buildings and grounds of Canadian Kodak Company, Ltd., Kodak Heights, Toronto. Floor space 500,000 square feet; employment 800. The power plant has latest equipment, automatically controlled; will develop 1800 h.p.; operates at steam pressure of 450 lbs. and steam temperature of 560° F. A 750 kw. turbo-generator, speed 8,000 r.p.m., supplies electrical power.

Below—International Harvester Company of Canada, Ltd. at Hamilton, Ont., make harvesting machines, seeding machines, tillage implements, ploughs, threshers and cream separators.



View of Three Rivers, Que., centre of Canada's greatest pulp and paper production. Foreground shows St. Lawrence Paper Mills Company, Ltd. Floor area 560,000 square feet; employees 500; daily output 450 tons of newsprint; approximate value of yearly output $4,000,000.

Canadian International Paper Company's mill at Three Rivers, Que., known as the world's largest paper mill with a rated capacity of 750 tons per day. The approximate value of output is $11,000,000 at present prices, and the average number of employees is 900.

General Motors of Canada, Ltd. Oshawa, Ont. Floor space 2,400,000 square feet. Production capacity 750 cars a day.

E. B. Eddy Company, Ltd., plant at Hull, Que., manufacturers specialty papers, toilet and tissue paper products, paper bags, newsprint and sulphite and groundwood pulps. Export toilet paper, towels, serviettes and newsprint. The ground floor area of plant is 458,500 square feet. Approximate value of output $5,000,000. Employees 1000

The Dominion Oilcloth & Linoleum Company, Ltd. Montreal. Area 544,200 square feet. Products linoleums, marble tile, wall coverings.

Below—Located at Ocean Falls on the Pacific coast about 300 miles north of Vancouver, B.C., the plant of Pacific Mills Limited turns out newsprint, kraft wrapping and paper specialties to an amount of 350 tons per day. The harbour is on tide water and is open all the year.

Plant at Drummondville, Que., of Canadian Celanese Limited; silks from cellulose acetate. Employ 2,300 people. Payroll $2,700,000 a year.

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Industrial Organization, to impose its will on Canadian workmen. This group initiated a strike in the automobile industry in Ontario, which was settled without recognition of the trouble fomenters. There is considerable unrest in labour circles.

## INDUSTRY IN 1935—A REVIEW

Nearly two thousand distinct articles or products are listed as being manufactured or processed in Canada in 1935. A tabulation showing forty leading industries, giving the number of establishments, capital invested, number of employees, salaries, cost of materials and gross value of products, as well as the same statistics for the total of all industries, is given in Table II.

This tabulation shows the industries in order of the gross value of their output. For the first time non-ferrous metal smelting and refining has exceeded that of pulp and paper. If, however, we add the output of sawmills to that of pulp and paper, these two exceed the smelting and refining group by over forty million dollars. According to salaries and wages paid, pulp and paper leads, followed in order by printing and publishing, central electric stations, automobiles, railway rolling stock, sawmills, electrical apparatus and supplies, bread and other bakery products, clothing factory (women's), hosiery and knitted goods. In order of gross value of products, pulp and paper is second, printing and publishing fourteenth, central electric stations third, automobiles fifth, railway rolling stock seventeenth, sawmills ninth, electrical apparatus and supplies tenth, bread and other bakery products eleventh, clothing factory (women's) fifteenth, and hosiery and knitted goods sixteenth.

The 25,491 Canadian industrial establishments had in 1935 a capital investment of $4,698,991,853, employed 582,874 people, paid out in salaries and wages $590,326,904, used materials to a value of $1,420,885,153, and turned out a gross value of products of $2,807,337,381.

Table III shows the distribution of industry by groups for 1935.

In the production and exportation of many staple products, including asbestos, newsprint paper and nickel, Canada led the world in 1935 and still does. In output of copper and zinc she occupied third place; fourth place in the production of gold and lead; fifth place in the manufacture of automobiles; and seventh place in yield of wheat. In that year the Dominion was first in the exports of asbestos, newsprint paper, nickel and wheat; occupied second place in the export of wheat flour; third place in the export of automobiles; and fourth place in the export of rubber tires and wood pulp. In world trade Canada in 1935, as well as in 1934, occupied sixth position in total

Table II

Principal Statistics of the Forty Leading Industries of Canada, 1935

| Industry | Establishments Number | Capital $ | Employees Number | Salaries and wages $ | Cost of materials $ | Gross value of products $ |
|---|---|---|---|---|---|---|
| 1. Non-ferrous metal smelting and refining | 15 | 145,686,299 | 8,944 | 12,687,356 | 126,804,075 | 186,245,658 |
| 2. Pulp and paper | 95 | 545,572,938 | 27,836 | 35,893,313 | 57,995,037 | 162,651,282 |
| 3. Central electric stations | 1,041 | 1,459,821,168 | 15,458 | 22,519,993 | | 137,114,911 |
| 4. Slaughtering and meatpacking | 139 | 58,207,715 | 10,674 | 12,448,347 | 108,191,810 | 133,379,312 |
| 5. Automobiles | 20 | 40,765,548 | 13,095 | 18,797,599 | 75,645,998 | 106,624,445 |
| 6. Butter and cheese | 2,589 | 58,291,763 | 14,786 | 13,905,135 | 69,953,193 | 99,888,971 |
| 7. Flour and feed mills | 1,127 | 56,475,315 | 5,454 | 5,165,507 | 78,071,667 | 97,567,868 |
| 8. Petroleum products | 58 | 64,707,454 | 4,856 | 7,153,224 | 58,869,814 | 79,950,525 |
| 9. Sawmills | 3,698 | 75,973,627 | 25,727 | 17,711,657 | 35,927,884 | 65,905,132 |
| 10. Electrical apparatus and supplies | 182 | 75,499,255 | 15,549 | 17,594,759 | 25,409,806 | 61,152,834 |
| 11. Bread and other bakery products | 3,045 | 43,788,924 | 19,167 | 16,369,912 | 28,343,545 | 59,400,678 |
| 12. Cotton yarn and cloth | 35 | 70,741,613 | 18,121 | 13,206,265 | 33,689,873 | 59,378,664 |
| 13. Rubber goods including footwear | 45 | 63,435,798 | 11,023 | 11,017,431 | 20,258,774 | 55,949,570 |
| 14. Printing and publishing | 793 | 53,721,846 | 16,889 | 23,061,512 | 11,197,377 | 55,832,925 |
| 15. Clothing factory, women's | 591 | 22,668,528 | 17,894 | 14,593,861 | 31,642,215 | 53,796.274 |
| 16. Hosiery and knitted goods | 163 | 50,048,900 | 18,511 | 14,252,653 | 22,948,056 | 46,390,103 |
| 17. Railway rolling stock | 37 | 86,547,010 | 16,921 | 18,785,671 | 20,769,208 | 41,213,039 |
| 18. Biscuits, confectionery, cocoa, etc | 234 | 37,779,319 | 10,446 | 9,315,563 | 19,231,189 | 41,197,833 |
| 19. Breweries | 73 | 57,928,298 | 4,460 | 6,155,642 | 15,024,625 | 40,699,040 |
| 20. Tobacco, cigars and cigarettes | 116 | 58,178,513 | 8,145 | 7,221,048 | 19,701,385 | 39,103,875 |
| 21. Castings and forgings | 303 | 63,585,479 | 13,760 | 14,138,972 | 14,042,882 | 38,779,813 |
| 22. Primary iron and steel | 53 | 86,465,490 | 9,523 | 12,279,390 | 18,539,072 | 38,700,961 |
| 23. Coke and gas products | 44 | 98,939,160 | 4,107 | 5,627,861 | 15,233,519 | 38,474,789 |
| 24. Fruit and vegetable preparations | 298 | 38,272,379 | 7,912 | 5,063,481 | 22,252,826 | 38,276,487 |
| 25. Sugar refineries | 8 | 33,017,874 | 2,134 | 3,086,691 | 25,137,568 | 36,597,997 |
| 26. Clothing factory, men's | 170 | 16,271,865 | 9,296 | 8,990,370 | 20,676,934 | 36,578,897 |
| 27. Boots and shoes, leather | 217 | 24,313,445 | 15,930 | 11,742,871 | 19,431,799 | 35,989,912 |
| 28. Sheet metal products | 129 | 47,369,004 | 6,580 | 6,802,698 | 18,971,146 | 33,564,302 |
| 29. Printing and bookbinding | 1,182 | 40,331,944 | 12,194 | 13,707,159 | 11,653,559 | 33,188,331 |
| 30. Machinery | 211 | 59,899,705 | 8,949 | 10,531,251 | 12,194,263 | 32,856,175 |
| 31. Automobile supplies | 82 | 23,260,333 | 6,614 | 7,411,434 | 18,528,296 | 32,684,252 |
| 32. Silk and artificial silk | 33 | 35,063,023 | 10,088 | 8,371,037 | 10,946,739 | 28,045,340 |
| 33. Coffee, tea and spices | 86 | 13,431,195 | 2,118 | 2,537,077 | 17,543,308 | 24,214,761 |
| 34. Boxes and bags, paper | 146 | 21,153,422 | 5,562 | 5,432,060 | 12,952,362 | 23,466,368 |
| 35. Fish canning and curing | 630 | 17,144,806 | 4,766 | 2,874,553 | 14,772,722 | 23,458,356 |
| 36. Furnishing goods, men's | 176 | 15,569,465 | 8,957 | 5,788,255 | 13,916,201 | 23,152,780 |
| 37. Medicinal and pharmaceutical preparations | 166 | 20,091,688 | 3,664 | 4,500,252 | 7,009,191 | 21,292,751 |
| 38. Leather tanneries | 85 | 22,982,210 | 3,967 | 3,920,106 | 12,991,558 | 20,497,553 |
| 39. Paints and varnishes | 80 | 22,709,466 | 3,060 | 4,242,116 | 9,610,743 | 20,341,407 |
| 40. Woollen cloth | 65 | 19,620,649 | 6,305 | 5,108,603 | 10,342,336 | 19,343,305 |
| Total, forty leading industries | 18,260 | 3,845,332,433 | 429,442 | 440,012,685 | 1,166,422,555 | 2,222,947,466 |
| Total, all industries | 25,491 | 4,698,991,853 | 582,874 | 590,326,904 | 1,420,885,153 | 2,807,337,381 |
| Percentage of forty leading industries to all industries | 71.6 | 81.2 | 73 7 | 74.5 | 82.9 | 79.2 |

The Manufacturing Industries of Canada, 1935, Dominion Bureau of Statistics.

Quarry and mill of the Quebec Asbestos Corporation, Ltd. at East Broughton Station, Que. The asbestos mines of Quebec have long supplied a major part of the world's demands. One company has sufficient asbestos-bearing property to last, at present rate of output, 100 years. Over 100,000 tons of asbestos valued at $5,300,000 were exported in 1935. Employment was provided in the mines and mills for 2,072 persons.

Noranda development in north-eastern Quebec of Noranda Mines Limited. This mine produces gold, silver, copper, selenium and tellurium; recovered (1936) metal to a value of $18,315,000. It exports copper, selenium and tellurium. Over 2,000,000 tons of ore were mined in 1936.

The smelter, lead refinery, zinc refinery, precious metals refinery and copper refinery of the Consolidated Mining & Smelting Company near Trail, B.C., is the largest non-ferrous metallurgical works in the British Empire. This Company is a subsidiary of the Canadian Pacific Railway Company, and owns the Sullivan mine, which is one of the most valuable mineral deposits in America, if not in the whole world. A $10,000,000 plant built a few years ago manufactures fertilizers. Smelter gases are used to produce sulphuric acid, surplus power to make electrolytic hydrogen, nitrogen is extracted from the air, and together with phosphate rock imported from the United States, large tonnages of ammonium sulphate, ammonium phosphate and super-phosphate are made.

The works of Shawinigan Chemicals Limited, producing calcium carbide and glacial acetic acid, is one of the largest in the world and the greatest of its kind in the Empire. Carbide is made from limestone and coke in electric furnaces. The acetylene gas therefrom is the base for acetic acid. Products are shipped to all parts of the world. The company employs about 1000 people and uses 75,000 h.p. of electricity.

The plant of the North American Cyanamid Limited at Niagara Falls, Ont., is the largest cyanamid works in the world. The products manufactured are cyanamid, cyanide and silicate of soda. Cyanamid is used as a fertilizer and is made by absorbing nitrogen in powdered calcium carbide at white heat. The capacity of the plant is over 350,000 tons. Nearly 1000 people are employed.

Exshaw Cement Works of the Canada Cement Company, Ltd., near Banff, Alberta. Canadian cement plants produced 3,648,000 barrels, valued at $5,580,000 in 1935. There were nine plants in operation, employing about 1000 hands.

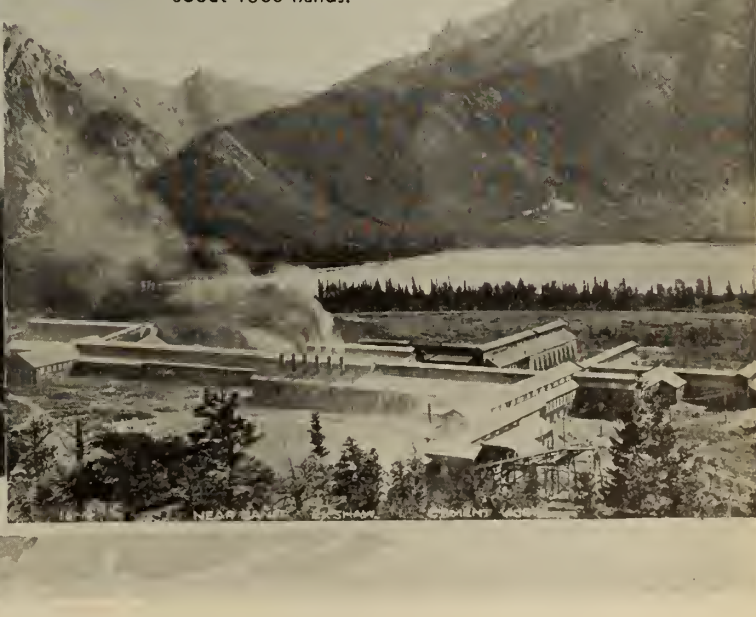

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Table III

Principal Statistics Compared by Groups of Industries

| 1935 | Establishments Number | Capital $ | Employees Number | Salaries and wages $ | Gross value of products $ |
|---|---|---|---|---|---|
| Vegetable products | 5,402 | 496,256,485 | 79,285 | 74,859,447 | 509,822,142 |
| Animal products | 4,402 | 211,672,508 | 60,124 | 54,035,134 | 351,643,587 |
| Textiles and textile products | 2,275 | 329,197,254 | 120,699 | 96,574,954 | 357,106,277 |
| Wood and paper products | 8,186 | 873,756,949 | 123,724 | 128,196,524 | 441,160,387 |
| Iron and its products | 1,249 | 555,144,467 | 95,426 | 110,402,366 | 390,228,929 |
| Non-ferrous metal products | 505 | 261,625,967 | 33,613 | 40,315,477 | 288,523,250 |
| Non-metallic mineral products | 1,188 | 300,455,725 | 23,342 | 27,425,224 | 176,184,717 |
| Chemicals and chemical products | 734 | 147,472,534 | 18,933 | 23,715,305 | 118,574,228 |
| Miscellaneous industries | 509 | 63,588,796 | 12,270 | 12,282,480 | 36,978,953 |
| Central electric stations | 1,041 | 1,459,821,168 | 15,458 | 22,519,993 | 137,114,911 |
| Total | 25,491 | 4,698,991,853 | 582,874 | 590,326,904 | 2,807,337,381 |

The Manufacturing Industries of Canada, 1935, Dominion Bureau of Statistics.

trade; ninth position in total imports; and fifth position in domestic exports.

The year 1936 saw an advance to fourth place among the trading nations of the world in export and fifth place in total trade, the latter amounting to $1,663,093,000, an increase of $274,435,000 over the previous years, showing a favourable balance of $617,000,000 over imports.

## WOOD AND ITS PRODUCTS

As already mentioned, the products of the forest have been of the greatest importance to industrial Canada. They provided for the construction of homes and buildings, the manufacture of furniture, vehicles, cooperage, shipbuilding, and during the period of this review have been the source of supply upon which mighty industries have developed.

When machinery was introduced and power replaced hand labour, the wood-working industry developed rapidly. The manufacture of horse-drawn vehicles was a leading industry when the Canadian Society of Civil Engineers was formed. Mass production and standardization of styles of doors and sash resulted in enormous increases in the product of the factories. Although much of the wood used in the manufacture of furniture is imported at the present time, factories using Canadian woods constitute an important industry. The proximity of great water powers to the pulp wood forests has made Canada the world's chief producer and exporter of newsprint.

The manufacture of sawn lumber is the second of the industries in Canada, which depend on the forest for their raw material. It is carried on by over three thousand establishments, from the gigantic mills of the Pacific coast, cutting as much as half a million feet board measure in a shift, to little custom mills on the Gaspé peninsula operated by windmills, cutting one or two thousand feet a day, with favourable winds.

Due to its importance, the pulp and paper industry deserves special mention. The superior quality of Canada's pulp and paper products has created a world demand. In 1935 Canada produced 3,868,341 tons of pulp, about 79 per cent of which was made in pulp and paper mills and used by them in paper making. Of the total pulp production 64 per cent was ground-wood, 17 per cent unbleached sulphite, 10 per cent bleached sulphite, 6 per cent sulphate. The total production of paper in 1934 was three million tons, of which newsprint and similar paper made up 84 per cent, paper boards 10 per cent, wrapping paper 3 per cent, book and writing paper 2 per cent, and miscellaneous paper the remainder. Conversion of many of these papers results in such products as napkins, towels, packaged toilet papers, coated and treated paper, envelopes, stationery and other cut paper and boards. Early in 1925 Canada's output of newsprint surpassed that of the United States. Since 1926 production in the United States has decreased, amounting in 1936 to slightly over 900,000 tons, while Canada's output was approximately 3,200,000 tons. Of the total Canadian newsprint exports of 2,993,000 tons last year 20 per cent went overseas and 80 per cent to the United States—new high figures to both destinations. Canadian overseas exports have more than doubled since 1928. They passed 500,000 tons for the first time in 1935 and reached 594,000 tons in 1936.

In 1935 wood and its products was Canada's leading industry in number of plants (8,186), employment (123,724 people), salaries and wages ($128,196,000) and in volume of output ($441,160,000) second only to that of vegetable products, and in invested capital ($873,757,000) second to that of central electric stations. While sawmills in 1934 were 43 per cent of the total number of establishments in this group, the ninety-five pulp and paper mills had an invested capital of over 60 per cent of the total and produced over 35 per cent of the value of manufactured products. Sawmills were second in output followed closely by printing and publishing, printing and bookbinding, boxes and paper bags; furniture; planing mills; sash and door factories; and other branches of the industry.

## TEXTILES IN CANADA

The Intendant Talon believed that French-Canadian colonists should clothe themselves either with the consent of the French authorities or in spite of them. He favoured domestic industries, and in 1671 wrote that he had caused druggets, coarse camlet, bolting cloth, serge, woollen cloth and leather to be made in the Colony, stating: "I have of Canadian make wherewithal to clothe myself from head to foot." Spinning and weaving were taught at their schools by the Ursuline Nuns. Almost every house had a flax spinning-wheel, a wool spinning-wheel and a hand loom, so that industrious women provided all the fabrics needed in the home, for bedding, carpeting and clothing.[9] The blanket coat of the snowshoers, the pattern of which is still preserved, was a production of that era.[10] The

[9] "Progress of Canadian Industries" by E. B. Biggar, from Castell Hopkins' "Canada, an Encyclopaedia of the Country."

[10] Young men might have been seen going about in colours that brightened the winter landscape. Gay belts of green, blue, red or yellow enriched the waists of their thick overcoats; their scarlet leggings were laced up with green ribbons; their moccasins were gorgeously embroidered with dyed porcupine quills; their caps of beaver or marten were sometimes tied down over their ears with vivid handkerchiefs of silk. The habitants were rougher and more sombre in their dress. A black homespun coat, grey leggings, grey woollen cap, heavy moccasins of cowhide—this grave costume was usually brightened by a belt or sash of the liveliest colours. The country women had to content themselves with the same coarse homespuns, which they wore in short full skirts, but they got the gay colours, which they loved, in kerchiefs for their necks and shoulders. (History of Canada by Charles G. D. Roberts, M.A.)

clothing mentioned in Roberts' history was made entirely of wool.

In 1768 Guy Carleton sent a report about the manufacturing situation to the colonial secretary, Lord Hillsbury, who was alarmed by the Canadian production, as he meant to keep the privilege of clothing the subjects of the Empire for the textile plants of England.

The manufacture of textile fabrics long continued to be a domestic industry. By the middle of the last century there were in Upper and Lower Canada and the Maritime Provinces, 385 carding and fulling mills and about 250 establishments where weaving was carried on in addition to the hand-loom weaving in the homes. The factory system in textile manufacturing increased with the growth of population, while home production diminished. We find in 1871 a yearly production of 7,640,000 yards of home-made cloth in the four provinces of the Dominion. By 1891 the production had dwindled in every province, having a total of only 4,300,000 yards, of which one-half was made in Quebec.

### Primary Textiles

*Woollens*

Ontario played a pioneering part in the establishment of the woollen industry in Canada. In Eastern Ontario at Galt and other places, at Cobourg in Central Ontario, and in Lanark County the woollen industry grew to an extent that the district was known as the Yorkshire of Canada. The largest woollen factory in Canada was located at Sherbrooke, Quebec. In 1891, the census year nearest to the period under review, there were 377 woollen mills; total hands employed—7,156; annual wages—$1,884,483; total products—$8,087,871. The output of the woollen establishments in Canada in 1920 was $28,000,000, which is the peak year in woollen cloth production. In 1934 it was less than $18,000,000, and has not increased with population or in proportion to the growth of textile industries as a whole.

*Cottons*

The cotton industry had its genesis in the middle of the last century.[11] There were in all Canada in 1889 twenty-five mills with 11,282 looms and 519,700 spindles. For twelve years there was no increase in the number of mills, then capable of supplying twice the population. This over-production resulted in amalgamations. Canada exported grey cottons to China in 1887. The cotton textile industry comprises: cotton yarn and cloth, cotton thread, cotton and wool waste, cotton batting and wadding, and cotton textiles.

*Linen*

The introduction of linen and hemp manufacturing in Canada was contemporaneous with that of the woollen industry. Records show that linen cloth making was introduced as early as 1668. Hemp growing was encouraged by both the French and English regime. The manufacture of home-made linen reached a total of one and three-quarter million yards in 1871, which in 1891 had decreased to 630,000 yards The attempts made to manufacture linen by machinery in Canada failed.

*Silk*

At a time when practically all other industries were experiencing a diminishing demand for their products, or were struggling hard to regain the 1929 level of production, this industry has since then recorded an increase of twenty-four per cent in capital investment, 131 per cent in number of employees, 119 per cent in salary and wage payments, 80 per cent in cost of materials used and 93 per cent in gross value of production.

The principal products of this industry are:—real silk, artificial silk, real and artificial silk mixed, including velvets, artificial silk and cotton mixed.

Ontario and Quebec accounted for all manufacturing activities in the silk industry. Of the thirty-three establish-

[11]The Canadian Textile Directory, 1889.

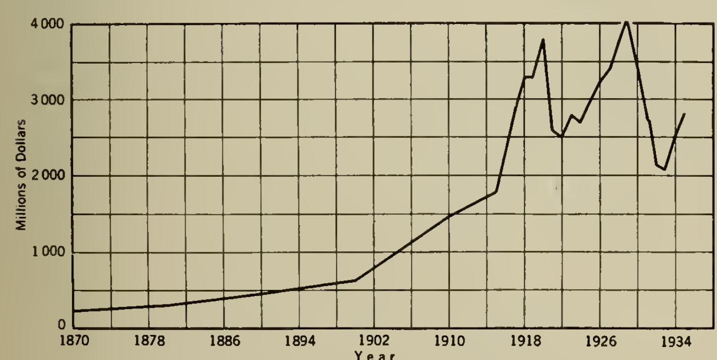


Fig. 1—Gross Value of Manufactures.

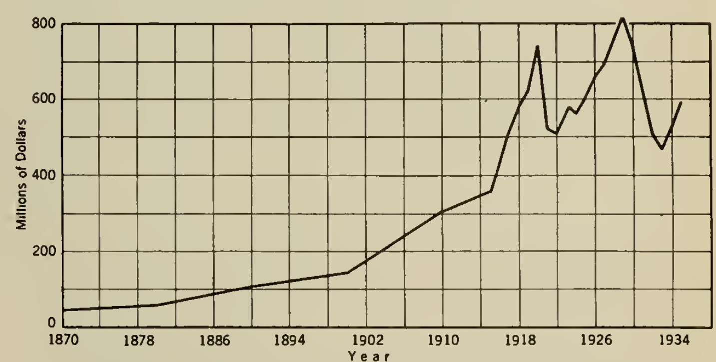


Fig. 2—Salaries and Wages Paid by Manufacturing Establishments.

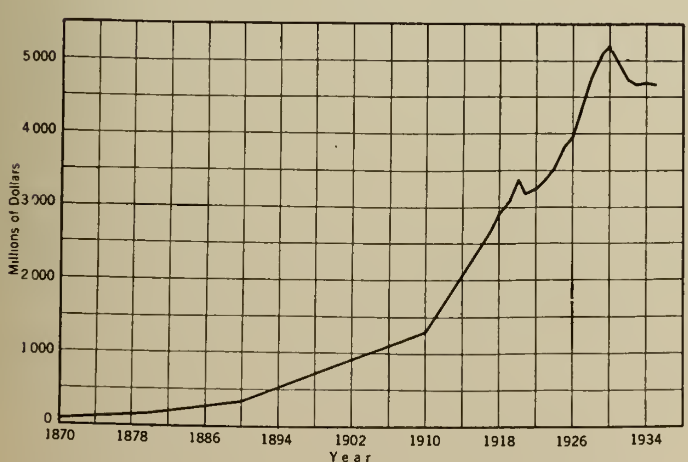


Fig. 3—Capital Invested in Manufacturing Establishments.

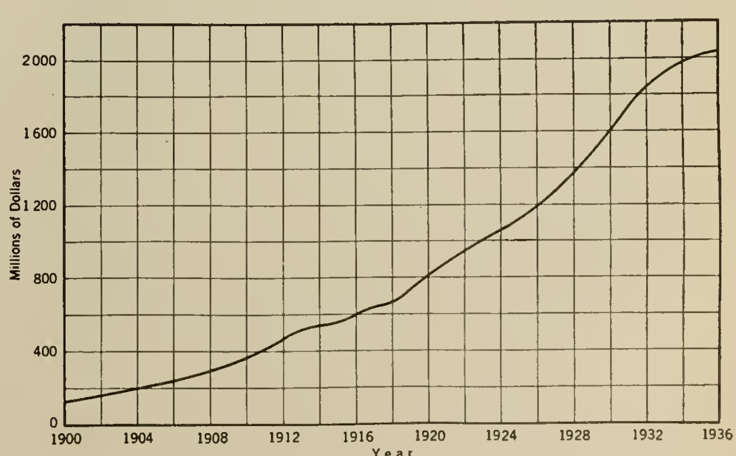


Fig. 4—Branch Plants in Canada.

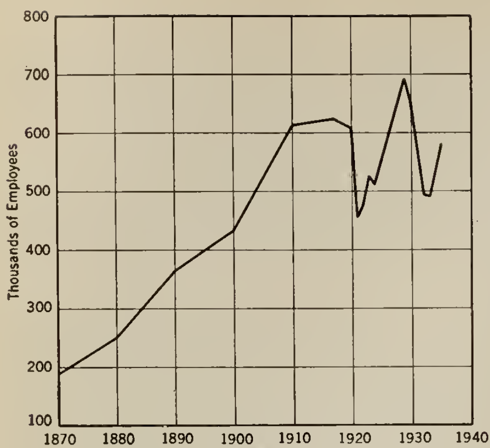


**Fig. 5—Employment in Manufacturing.**

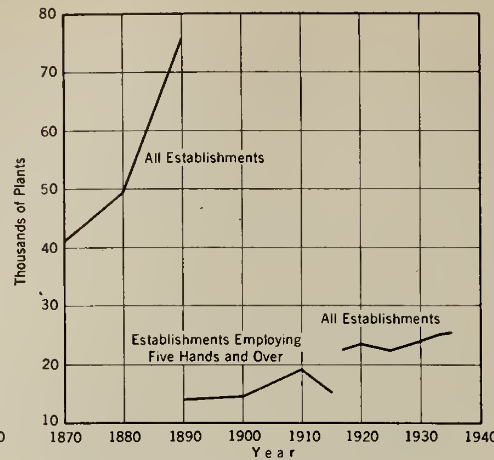


**Fig. 6—Number of Manufacturing Establishments.**

ments, eleven were situated in Ontario and twenty-two in Quebec. The brightest feature of the textile industry during recent depression years was the progress made in the manufacture of that industrial marvel, rayon, and the progressive growth of both the silk and rayon industry.

*Rayon*

The history of Canada's rayon industry is meritorious. Consumption of rayon yarn in this country during the past ten years increased from 3¼ million pounds to 13¾ million pounds, over ten million pounds of which was produced by Canadian plants, one at Cornwall, manufacturing viscose yarns, and the other at Drummondville, manufacturing cellulose acetate yarns. The two plants employed 4,300 workers. Their record is an enviable one, as they have during that period brought into being a major Canadian industry. The increase in volume was paralleled by constant improvement in quality, so that the fabrics made in one plant and the yarns in another, which are woven in many establishments, can compare in quality with anything produced in the world. In its report for the year 1935, the Dominion Bureau of Statistics shows 10,000 persons employed and a total production of $28,045,000.

*General*

The war brought about a modernization of the textile mills of Canada, due to the great demand for the army and civilian population. The depression was responsible for greater efficiency obtained by improvements in plant equipment and organization.

The primary textile industry in Canada comprises a total of 476 mills and includes:— 49 cotton manufacturers; 104 woollen and worsted manufacturers; 180 knit goods manufacturers; 34 silk and rayon manufacturers; 8 plush, velvet and upholstery manufacturers; 1 linen manufacturer; 12 carpet and rug manufacturers; 11 cordage and rope manufacturers; 16 dyeing and finishing; 14 waste and shoddy manufacturers; 34 labels, ribbons and narrow fabric manufacturers; 14 felt manufacturers.

During 1934 the primary textile industry employed 61,061 people and produced a gross value of products of $190,614,000, while the secondary textile industry shows 1,731 establishments and 54,634 employees, and produced a gross value of products of $151,440,000—a total textile production of $342,054,000. Rising commercial prices have given the industry an impetus which indicates that the present year will be the best not only in point of production but from the number employed. The industry employed as at April 1937 sixty-six thousand hands.

During the year ended January 1937 Canada exported fabrics, textiles and textile products to a value of $12,615,000.

### Clothing

In the period of Canadian history until about 1870 there is no record whatever of the establishment of what might be described as "clothing factories." Until that time clothing was either made in the homes of the people or in the case of men's clothing, made by tailors who operated small shops, making clothing to measure for individual customers. In the country districts, itinerant tailors journeyed from village to village and from house to house, carrying with them their shears and tailors's goose. They were supplied with cloth, usually made in a local woollen mill, frequently from wool supplied by the farmer from the backs of his own sheep. Women's clothing was made at home or by dressmakers, sometimes employing a number of other women in their own homes or small shops, but usually by women who visited the homes of those who required and could pay for their services.

The first census of Canada which makes any mention of clothing factories is the census of 1901. Earlier census records show large numbers of clothiers, tailors and dressmakers.

Strong contrasts are found in what is known as the secondary textile industry of Canada. In the primary industry some of the shrewdest business minds of the

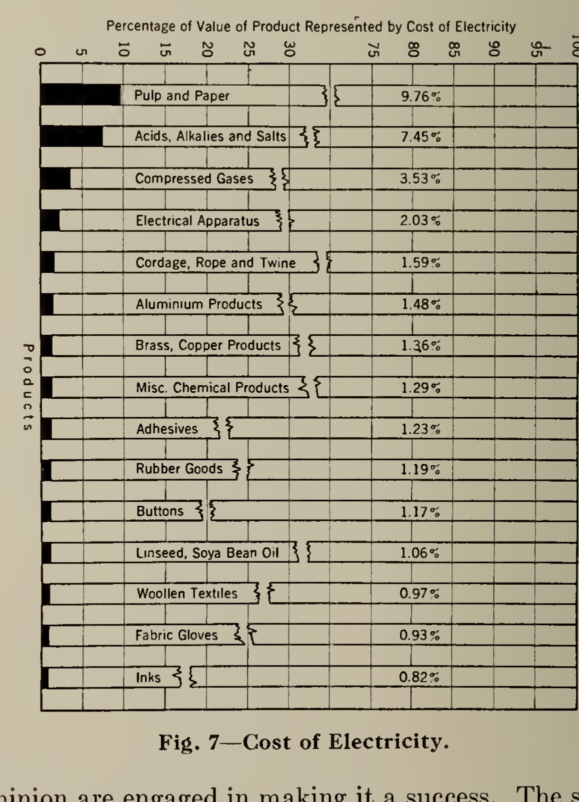


**Fig. 7—Cost of Electricity.**

Dominion are engaged in making it a success. The same is true of some well-organized establishments in the secondary industry. There are about one thousand[12] manufacturers of wearing apparel of one kind or another, the outcome of the contract shops and the establishment of the manufacture of shirtwaists in the "nineties." This industry employed 54,634 people in 1934, being second only to the primary textile industry with its 61,000.

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[12]Fraser's Directory.

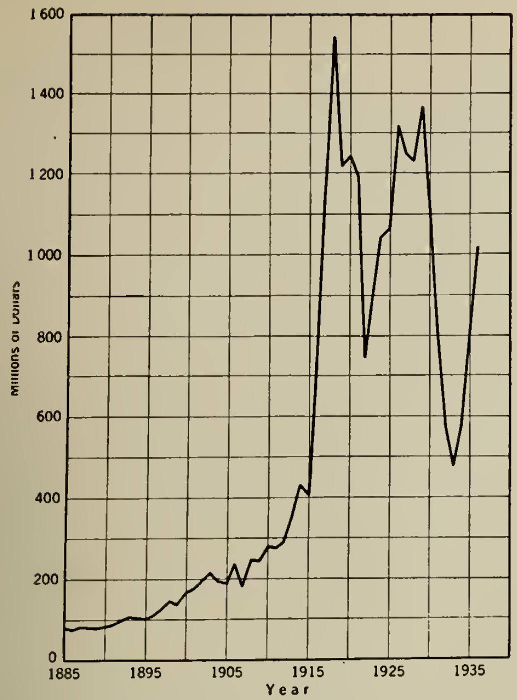


Fig. 8—Exports of Canadian Products.

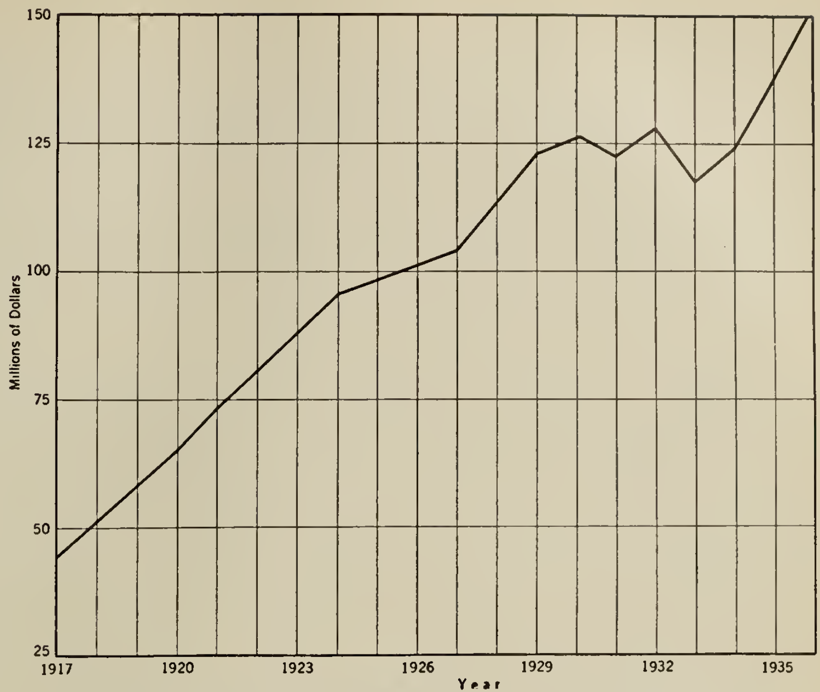


Fig. 9—Central Electric Stations value of Power Produced.

The Price Spreads Commission, appointed to investigate industrial profits, as well as the economics of labour conditions of the industries, in its report said of the secondary textile industry:—"Characterized by economic instability and excessive competition with contract shops and 'home workers' alongside the usual type of manufacturer, this industry though it includes many progressive and socially minded members, has had on the whole a doubtful record. The evidence we have taken shows that in many cases this record is only too well deserved."

There is a high mortality in the clothing industry.[13] Reports show that about 12 per cent of the firms engaged in men's wear industry and 18 per cent in women's wear industry fail each year. A great majority of establishments are conducted by men with little business experience, small capital and lacking in organized leadership.

From the homespun of the pioneer this industry has evolved through a remarkable cycle. The influence of the chemical engineer, the electrical and the mechanical engineer on the textile industry during the past fifty years has been profound.

## IRON AND STEEL AND THEIR PRODUCTS

Canada has pioneered in the metal-working industry. In 1733 the first metal-working industry on the continent was started at the Old Forges, on the St. Maurice river, a few miles north of Three Rivers. The quality of the iron manufactured from these ores was excellent, rivalling the finest made in Sweden. It is recorded[14] that in 1737 one hundred men were working at the plant, which was capable of supplying the working tools and household utensils required by the pioneers in their every day life.

In 1887 iron ore was produced to an amount of 76,330 tons, valued at the mines at $146,197. Four blast furnaces were operated, one at Londonderry, Nova Scotia, two at Drummondville, Quebec, and the Radnor furnaces at Three Rivers. The amount of pig iron produced was 24,827 tons.

The manufacture of machinery, tools and implements was a considerable industry in 1891. Nearly fifty thousand people were employed in over twelve thousand establishments, which had an output of over sixty million dollars. Thus, while industries employing wood products then led, the metal-working industry was already becoming an increasingly important factor.

At present three companies in Ontario and one in Nova Scotia are the only concerns in Canada making pig iron. The Ontario works depend upon foreign ore and coal, but the Nova Scotia plant uses local coal and iron ore from Newfoundland. The capacity of the blast furnaces operated is one million and one-half long tons of pig iron per annum. These companies, which represent the primary iron and steel industry, also operate open hearth steel furnaces and rolling mills, which produce steel ingots, blooms and billets, bars, rods, rails, structural shapes, plates, sheets and other material.

The selling value of the products of the iron and steel industry at the works, according to the preliminary statistics of 1935, is $388,542,774, from a total of 1,261 plants, employing 94,786 people, a capital investment of $548,467,111, and paying salaries and wages of $110,341,786. Castings and forgings number 275 plants, employ 10,701 people, while railway rolling stock with thirty-seven plants employs 16,921, and the twenty automobile establishments 13,095. The primary iron and steel industry employs 9,777 people in fifty-three plants. Machinery manufacturing numbers 202 plants, hardware and tools 134, metal plants 128, automobile parts 81, wire and wire goods 69, boilers, tanks and engines 51, agricultural implements 34, bridge and structural steel 18, bicycles 4, miscellaneous iron and steel 94. Exports advanced from $37,402,000 in 1934 to $50,027,000 in 1935. The number of establishments since 1917 has decreased by 150 and the number of employees is two-thirds of that in 1917 and 35,000 less than in 1929.

During the year ended January 1937, Canada imported iron and its products to a value of $139,616,000, of which $22,157,000 was from the United Kingdom and $112,097,000 from the United States. During the same period Canada exported iron and its products to an amount of $52,382,000, of which $12,674,000 went to the United Kingdom and $5,958,000 to the United States.

## CHEMICAL PRODUCTS

As is the case with many other industries, the availability of hydro-electric power and the demands created

[13]Manual of the Textile Industry of Canada, 1936.
[14]The General Dictionary of Canada, The Rev. Father LeJeune.

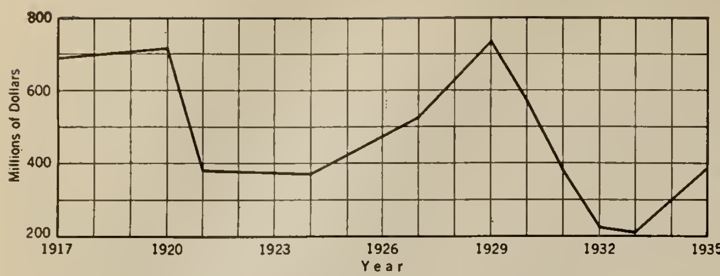


Fig. 10—Iron and Iron Products, Gross Value.

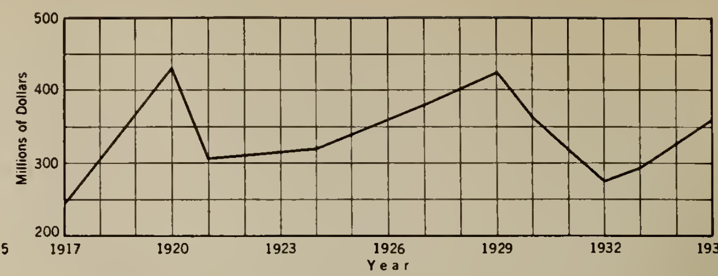


Fig. 11—Textile and Textile Products, Gross Value.

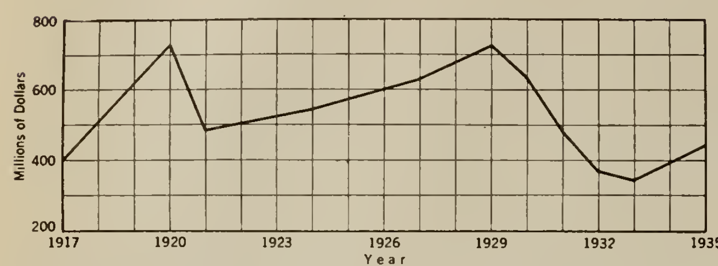


Fig. 12—Wood and Paper Products, Gross Value.

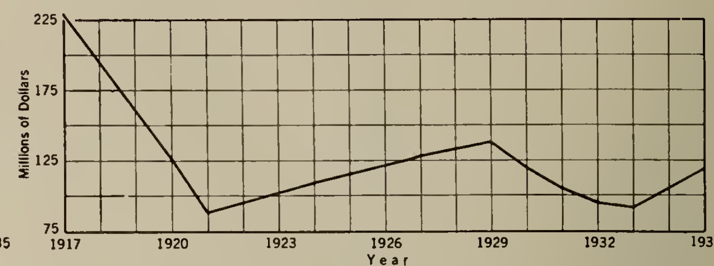


Fig. 13—Chemicals and Allied Products, Gross Value.

by the war have been the great contributing factors to an industry which today plays an important part in Canada's economic welfare. Eighty per cent of the country's requirements for chemicals and allied products are manufactured in the country, in addition to which the export trade has assumed considerable proportions, amounting to $16,372,000 in 1935, which was about 15 per cent of the production.

PETROLEUM

As one of the non-metallic group of minerals, petroleum is important. Many industries have been stimulated by the automobile, but its use has really created the petroleum products industry as we know it today.

There were, in 1921, eleven petroleum refineries in Canada. 1935 records report forty-five, distributed as follows:—Saskatchewan 14; Alberta 9; Ontario 7; Quebec 4; Manitoba 4; British Columbia 4; other provinces 3. These refineries used 1,196,411,000 gallons of crude oil, with operation to 58 per cent of capacity. Gasoline production amounted to 513,716,000 gallons, which was the highest on record. The industry gave employment that year to 4,771 people and had a selling value of products at the works of $79,175,000.

THE FISHING INDUSTRY

Fisheries of the Maritime Provinces, British Columbia, Yukon, the North-West Territories and the Magdalen Islands are controlled by the Dominion government. The non-tidal fisheries of the Maritime Provinces, Ontario, the Prairie Provinces, and the tidal and non-tidal fisheries of Quebec are controlled by the respective provinces. The Dominion operates twenty-four main hatcheries, nine subsidiary hatcheries, eight salmon retaining ponds, and distributed in 1933, 109,500,000 pounds of eggs, fry, and fish, both salmon and trout. Biological research stations are established at Halifax, St. Andrews, Nanaimo and Prince Rupert. The Canadian fishing grounds are among the most valuable in the world.

Fishing is one of the oldest and most historical of Canada's industries, having been carried on since the earliest days of the French regime. Deep-sea fishing commenced in 1873. There are nearly sixty different kinds of fish on the list, the most important of which are:—salmon, lobster, cod, herring, whitefish, halibut, haddock, pickerel and trout. In 1935 there were 68,557 fishermen employed, and in addition 14,360 in fish-canning and curing establishments. The industry has an investment of $43,617,000 and the output a market value in 1935 of $26,677,801, the greater part of which is exported.

THE FUR TRADE

The furs of the forests were the most esteemed of all their assets in Canada's early adventurous days. The northland still contributes liberally,—at present 66 per cent in value—but the largest single item—silver fox—is now a farm production, showing an increase in every year since 1920. The fur trader of the early days secured his pelts from the Indians. Since the Great War, Montreal has become an international fur market, the first Canadian fur auction being held in 1920. Fur auction sales are held also at Winnipeg, Edmonton and Vancouver. All provinces in Canada have enacted laws to regulate the capture of fur-bearing animals, provide for closed seasons, and work in co-operation with the Dominion government.

Besides the fox—mink, racoon, skunk, marten, fisher, muskrat and beaver are raised in captivity. In 1935, 4,926,413 pelts came on the market, valued at $12,843,000. The highest priced fur is the fisher, averaging $45.62 per pelt; the second is the silver fox at $36.06. In value the silver fox leads, followed in order by the muskrat, marten,

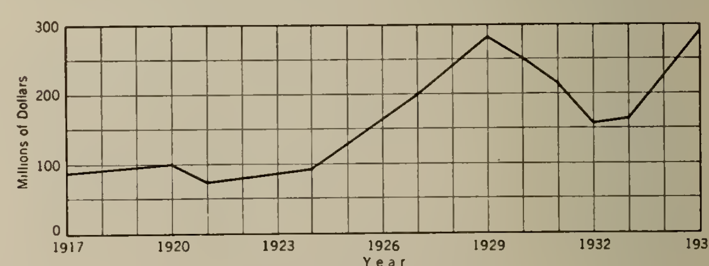


Fig. 14—Non-Ferrous Metals, Gross Value.

white fox, the red fox, and the cross fox. Of the nearly five million pelts marketed in 1935, Alberta led with 1,850,000, followed by Saskatchewan supplying over 1,000,000, and the yield from the other provinces is, in order:—Ontario with 686,342, Manitoba 490,295, Quebec 299,279, North West Territories 212,414, British Columbia 200,351, Nova Scotia 66,828, New Brunswick 55,184, Yukon 41,309, Prince Edward Island 19,828.

### MAPLE SUGAR AND SYRUP

The foundation of the maple sugar and maple syrup industry in the Dominion was laid in Canada by the early French settlers some two hundred and thirty years ago. It is now a substantial industry and guarded by a special act. Quebec is the centre of the industry and accounts for 75 per cent of the marketed Canadian production. Fifty thousand Canadian farmers produce syrup or sugar from twenty-four million trees, being only one-third of possible use. This industry produced a revenue of $3,714,000 in 1936, over eight million pounds of this sugar being shipped to the United Kingdom during that year.[15]

### EXPORTS OF CANADIAN PRODUCTS

In 1887 Canada's total exports were $89,515,000. These continued to increase with declines in 1905 and 1907 until 1914, the year in which Canada entered the Great War. The tremendous requirements for Canadian products, coupled with the manufacture of munitions, a heretofore unbelievable industrial expansion, and the rapid increase in cost of materials, brought the exports of Canada to a record peak in 1918 of $1,540,000,000. In 1922 this had fallen to $740,000,000, increasing rapidly in 1926 to $1,315,000,000, decreasing in 1927 to 1928 and reaching in 1929 a total of $1,363,000,000. Then followed a rapid decline until 1933, when the total had dropped to $473,000,000. Since then the improvement has been almost as rapid as that of the war years, so that in 1936 Canada's exports have again exceeded one billion dollars. Forest products—newsprint paper, wood pulp, planks and boards, and shingle wood exports—amounted to $154,163,000. exceeding in value that of wheat which was $148,577,000.

In 1936 total exports of Canadian merchandise were $1,027,902,000, which was an increase of 22.6 per cent over the preceding year. The total of twenty-four leading nations showed an export increase of only 6 per cent. The imports were $635,191,000.

### THE PRESENT ERA

A general economic recovery, existing reciprocal trade agreements with many countries, notably the British Empire and the United States, war preparedness demands, exchange stability, modern mechanical equipment, efficient industrial processes, higher prices and greater markets for wheat and other food products, for nickel, asbestos, aluminum, zinc, lead, iron and steel products, chemicals, textiles, lumber, pulp and paper, and the tourist trade, have rapidly improved Canada's position during the present era, which commenced four years ago. An agricultural yield of over one billion dollars in 1936, increased production of pulp and paper, chemicals and chemical products, record output of non-ferrous metals and other products, of central electric stations, and monthly increases in exports during 1937, indicate a condition comparable with the boom period of the Twenties.

### CONCLUSION

Facts and figures, already given, leave no doubt as to the material progress made in industry and manufacturing in Canada during the half century just past, in which electricity and the engineer have played principal parts. The engineer has yet another rôle if he would fulfil his destiny. Twenty years ago the author, at a meeting of the Ottawa Branch of The Engineering Institute of Canada, uttered these, so far not prophetic, words:—

> "The lawyer and the politician have admittedly failed to solve the industrial relations of man to man and the relations between capital and labour. The very qualifications of mind and training that have enabled the engineer to so successfully grasp and solve any problem set before him will be called upon and required to solve and to deal with what will be, after the war, the greatest problem which we have to face."

Today's worker in Canada produces four times as much in value of output as his grandfather did. He is paid four times as much. He works fewer hours. He enjoys standards of living then unknown. Labour on this continent is being organized and misled by leaders, whose lust for power knows no limitations. The labour situation grows more and more like that which created dictatorships in Europe, which, having used labour to gain power, later regimented and made it inarticulate. This country's population has doubled since 1887. Now, there are only 57 per cent more workers engaged in industry, which produces six times as much in value of output. Mechanical-electrical engineer-created machines and appliances have done much to create a social situation that needs a remedy and towards which the engineer has a responsibility.

The problem of stabilizing our whole production machine and rationalizing the human element, which includes putting youth to work, retirement of older men, employee-management relations, employee welfare, time and wage schedules, needs scientific treatment and the application of the engineer's mind. The present economic system requires more basic interpretation and more definite codification. The mechanism of human relationships in industry is due for overhauling and neither legislation nor labour organizations can do it.

If those who are guiding the destinies of The Institute were to make the solution of this unsettled problem a principal item on its programme, and its members succeed in finding that solution, which assuredly they can, The Institute will not only have increased its prestige, but the engineer will have exalted his profession by giving direction to a troubled humanity, that needs leadership to bring into being a new order in social affairs.

#### Illustrations

The illustrations, besides giving a glimpse of industry in Canada's earlier days, are included for the purpose of showing, even briefly, the style of modern factory buildings and the extent of some of Canada's industries.

#### Acknowledgments

In addition to the references already mentioned, acknowledgment is made of photographs supplied by the Canadian Manufacturers Association; Canadian Pacific Railway; National Development Branch, Department of the Interior; Natural Resources, Intelligence Service, Department of the Interior; Canadian Airways Limited; and many companies whose plants are illustrated. Appreciation of information supplied and assistance rendered is expressed particularly to Dr. R. H. Coats, and the able members of his efficient department, The Dominion Bureau of Statistics; to the McGill Library; to The Engineering Institute library; to the Public Library of Toronto; to the Library of the Legislative Assembly of Ontario; to the Statistical Department, Province of Quebec; to the Secretary of the Montreal Board of Trade; to the editors of Industrial Canada, Monetary Times and the Montreal Gazette to Mr. Frank Whitcomb and Mr. E. V. Leipoldt.

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[15] The chemical industry, fast becoming great, and mineral production, making new records every year, are important features of Canada's industrial fabric. As each of these is a subject of a separate paper of this series they are mentioned but not in proportion to their industrial significance. Individual industries such as boots and shoes, which has an interesting historical background, and those non-ferrous metals, asbestos, nickel and aluminum, which are of such economic importance, and others of a lesser value, might well have been included in a more extended review.

Fig. 1—Seymour Falls Water Intake, Vancouver, B.C.

# Progress in Sanitation

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*Chief Engineer, Quebec Ministry of Health, Montreal, Que.*

A review of the developments which have occurred, during the last fifty years, in the "adoption of sanitary measures conducing to the preservation of health" would mean writing the history of modern sanitation. The use of solid culture media in bacteriology and the germ theory of disease date back to the early eighties.

In 1874, the Rivers Pollution Commission of England stated in its Sixth Report that "the existence of specific poisons capable of producing cholera and typhoid fever is attested by evidence so abundant and strong as to be practically irresistible. These poisons are contained in the discharges from persons suffering from these diseases." It had been observed that sewage polluted waters could be the cause of disease, but foul air was also considered dangerous.

The same report contained this historical statement, well known to sanitarians: "There is no river in the United Kingdom long enough to secure the oxidation and destruction of any sewage which may be discharged into it, even at its source."

The studies made in England were closely followed in America, and the State of Massachusetts, where sanitary conditions resembled those prevailing in England, became a leader in sanitation on this side of the Atlantic. The State Board of Health, created in 1869, had advisory rather than executive functions, and one of its first circulars contained this declaration of rights as regards public health: "We believe that all citizens have an inherent right to the enjoyment of pure and uncontaminated air, water and soil, —that no one should be allowed to trespass upon it by his carelessness or his avarice or his ignorance."—These high ideals could not be put into force, and numerous recommendations contained in subsequent reports of the Board show that its work remained of an educational nature for several years.

In Canada, public health measures were taken at times of epidemics only, through a Central Board which Parliament could appoint. The English practice of creating local boards of health was largely followed. Sanitary conditions were better than in England and Europe, due to our small population scattered over a large territory.

Modern sanitation began with the creation of Provincial Boards of Health in Ontario in 1882, in Quebec and New Brunswick in 1887, and later in the other provinces. The powers granted were of an advisory character at first, but it was soon felt that more than persuasive action would be necessary to secure better co-operation from the local boards of health.

In 1895 the Boards of Health of Ontario and Quebec required that plans of water supplies and sewerage systems be submitted for approval; however in 1908, sanitary engineering divisions were created in order to secure better control of new works, and to apply remedial measures to some of the previous works.

### Water Supplies

In 1885, there were sixty water-works plants in Canada. The larger towns had realized early the necessity of such a public service; the systems were mostly of the gravity type and fed by springs or lakes. Improvement in pumping machinery and the introduction of cast iron pipe so facilitated the installation of new works, that twenty-five years later, the number of plants had reached the figure of four hundred and twenty.

The transmission of electricity and the advent of the centrifugal pump, reducing the cost of pumping installation, permitted the smaller municipalities to build water-works. The total number of works in Canada to-day is twelve

Fig. 2—McTavish Reservoir and Pumping Station, Montreal.

hundred and sixty, serving a population of 6,000,000 people, 54 per cent of the total population of the country.

The following statement is taken from a report of Sir John Simon published in 1867:— "My reports are incessantly showing the foulness of private supplies, while as regards public water supplies—it has again and again been shown that their conveniences and advantages are

THE HEAD OFFICE of the Sun Life Assurance Company of Canada—a magnificent monument to Canadian business enterprise and engineering skill. The corner-stone of the first part of the building was laid in 1914 and the corner-stone of the present structure in 1923. The ground area is 80,000 square feet and the total gross floor area (exclusive of three basements) is 1,174,000 square feet. The height is 399 feet (24 storeys).

*Illustration through the Courtesy of the*
SUN LIFE ASSURANCE COMPANY OF CANADA

countervailed by dangers to life on a scale of gigantic magnitude."

Sir. John Simon was referring to the numerous epidemics of cholera in London, where the relation between the prevalence of the disease and the impurity of the water supply had been observed.

Filters were first used to remove turbidity. Chemical improvements as shown by analysis were disappointing, though filtration seemed to be beneficial to health. Bacteriology revealed the removal of germs. Until 1870, there were no water filtration plants in America. The results of the Lawrence Experiment Station in Massachusetts in 1890 proved the efficiency of slow sand filtration and led to the installation of several plants in United States.

At the same time rapid filters had been installed in various municipalities, but it was after the classic experiments of Geo. W. Fuller, on the purification of the Ohio river at Louisville and Cincinnati in 1895 and 1898, that this type of filtration was placed on a par with the older type.

The American practice was adopted in Canada whenever filtration was required. The necessity for the purification of public water supplies was felt only after 1900, as up till then many sources of supplies were not seriously contaminated. However, numerous epidemics of typhoid fever were necessary to convince municipal corporations that a pure water supply was a good investment.

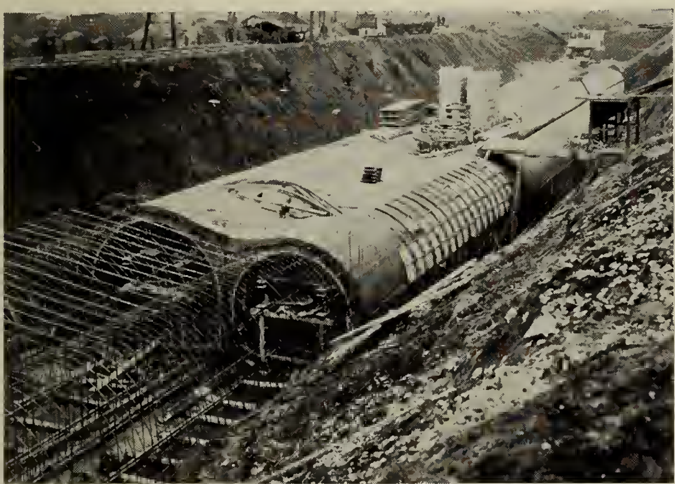


**Fig. 3—St. Pierre River Collector, Montreal. Inside dimensions of Twin Section 14 ft. by 14 ft. 6 in. and 16 ft. by 17 ft. 6 in.**

The first large slow sand filter was built in Toronto in 1912, and Montreal commenced a similar plant of a modified type the following year. The cost of these filters precluded their use by small towns, which resorted to rapid sand filters of the pressure or gravity type. Pressure filters were first used around 1905, in New Brunswick, and gravity filters in Quebec, in 1910. There are in Canada to-day, one hundred and twenty-five filtration plants, serving a population of approximately 3,000,000 people.

Chlorination has been a great help in bringing improvement to many small and large supplies. After the use of chloride of lime by Colonel Geo. A. Johnson, in Chicago and Boonton, in 1908, the adoption of the process spread very rapidly. Montreal thus treated its water in 1910, pending the construction of its filtration plant.

Liquid chlorine soon replaced hypochlorite of lime and it is used to-day in 260 plants, either alone or in conjunction with filtration. The total population thus protected is over 4,000,000.

The art of water purification has reached a high degree of development. Bacteria, colour, turbidity, and odour can be removed with assurance. Its application has reduced typhoid fever death rates in Canada from 30 per 100,000 in 1910, down to less than 2 in 1937.

### Sewerage

Strangely enough it was strictly forbidden to discharge any sewage into the first sewers built. Their object was to remove surface and drainage waters only. However, the temptation was too great, not to so dispose of wastes, and the sewers became elongated cesspools.

Water courses receiving the natural drainage of the land were first walled in, and finally covered, when too foul. Smaller drains built by private initiative or otherwise were soon connected to the larger sewers, and effluents from overflowing cesspools were finally admitted into the system. The water carriage system has been developed by the method of trial and error, by experience more than by experiment.

Flooding of basements and cellars was of frequent occurrence with the early systems; the capacity of sewers as well as the amount of sewage and storm water to be transported were poorly established. Silting of sewers was too frequent, causing the sewer gas which was so much feared.

The installation of sewers in Canada followed the construction of the water-works. English and American practice largely inspired the Canadian works; conditions requiring sewerage arose in the United States several decades before they did in Canada. Moreover, large rivers and smaller centres of population facilitated the solution of such problems.

Reliable statistics showing the growth of sewerage systems in Canada are difficult to obtain. A compilation made by the Conservation Commission in 1915 gives a total of two hundred and eighty systems and 75 disposal works. Today, all cities and towns are sewered and most of the villages are served by private or public sewers. Interceptors are built to reduce the number of outlets or to collect the sewage preparatory to treatment.

The important question of how to deal with the sewage at the outfall was easily solved in most cases: disposal by dilution. Montreal and one inland town applied the sewage to the land after the early English fashion, and with similar results. The soil being unsuitable, the system had to be abandoned.

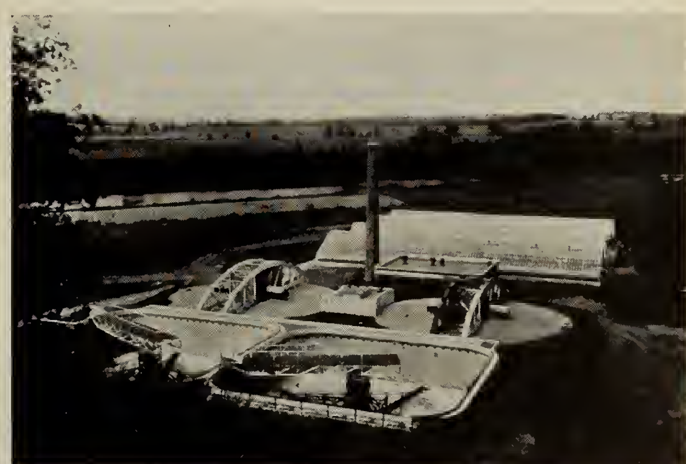


**Fig. 4—Separate Sludge Digestion Plant, 4 m.g.d., Kitchener, Ontario.**

The biological decomposition of sewage in tanks instead of on filters, developed by Cameron in 1895, was expected to produce complete liquefaction. The "septic tank" held public favour for over a decade, and several installations were made even in places where not needed. The problem had not been solved; the effluents were dark offensive liquids and the sludge difficulty remained. The Imhoff or two-storey tank, which is a modification of the Travis tank, was a marked improvement over the septic tank. It was eagerly adopted in Canada and especially in the United States, after 1910.

Contact beds were never popular in this country; percolating filters offered a better means to obtain oxidation of the organic matter, when low dilution required a high degree of purification. The filter area needed for the treatment of large volume of sewage brought the activated

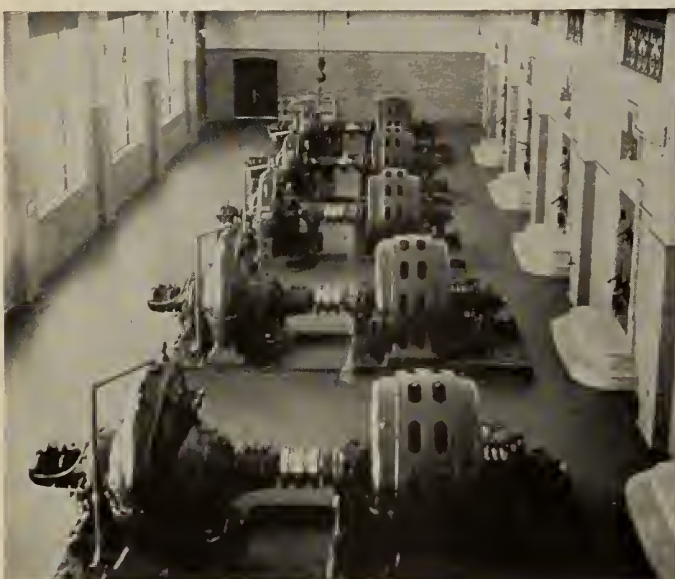


**Fig. 5—Main Pumping Station, Montreal. Highlift Pumps.**

sludge process, which consists in the oxidation of the sewage in tanks instead of on solid material. Experiments made about 1916 proved successful and the method was readily adopted.

The process consists in bringing the sewage into intimate contact with the proper kind of micro-organisms in the presence of an excess of air; it produces a stable effluent and removes a large percentage of the bacteria present in the raw sewage. An activated sludge plant requires expert supervision and can be more easily abused than a percolating filter. The latter still offers a better solution to the sewage disposal problem of the small town.

In recent years the mechanization of the sewage disposal plant has come to the fore. The importance of the object to be obtained has been given more consideration. A method of treatment is no longer adopted simply because it has been successful elsewhere. Each problem is studied and a selection or a combination of proved methods is chosen to satisfy the requirements. Chemical precipitation, which had been abandoned, is receiving favour; new chemicals and a better knowledge of the chemistry of sewage have brought the change. Chlorination of partly clarified sewage is used to protect beaches or prevent undue bacterial pollution of water courses.

There is a public demand for cleaner streams; methods have been devised to purify sewage to any desired degree before it reaches the stream. Disposal by dilution offers economic advantages which are lost to the community at large, when the method is abused.

### Garbage Disposal

The collection and disposal of garbage has retained the attention of the engineer. The dumping ground has been abandoned by large and medium size towns. The hog farm which has always been a messy method of reclaiming value from garbage has lost its glamour. The Beccari process of garbage digestion requires a climate that a northern country does not enjoy.

The incineration of garbage has progressed since the first installation made in Montreal in 1885. Better furnaces have been devised, producing higher temperatures. Recent developments make it possible to burn sewage digested sludge with the garbage, and to use the gases produced by the decomposition of the sludge as additional fuel.

During the last three years a new process has been tried in the United States. It consists in collecting the garbage at a receiving station, where it is ground to a pulp and then discharged into the nearest sewer. The operation is reported to be successful and does not interfere with the subsequent treatment of the sewage—provided the plant has sufficient capacity.

The discharge of ground garbage into sewers, however, must not be attempted until all factors have been studied and the method proved to be economically sound.

### Conclusion

Fifty years ago bacteriology, although in its infancy, had demonstrated the germ theory of disease. The sanitation engineer was called upon to apply this new knowledge, as well as the subsequent discoveries of the biologist, to the solution of sanitary problems. The suppression of many scourges which afflicted humanity proves how well he has succeeded.

The engineer can well be proud of the part he has played in reducing the general death rate in Canada from 14.4 per thousand in 1887, to 9.2 in 1936. He has also contributed his share in increasing the expectation of life at birth, from forty-seven years to sixty years. If health is the capital of the labouring class, he has also contributed to the wealth of his country.

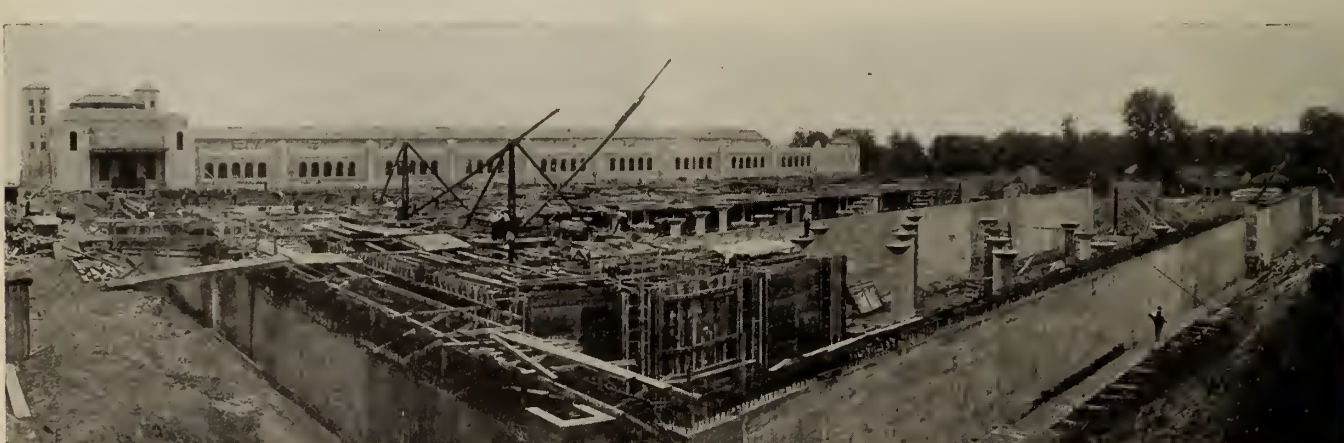


**Fig. 6—Northerly Elevation of Victoria Park Filter House, Toronto. Mixing and Settling Tanks in Foreground.**

# Lighthouse Engineering

*J. G. Macphail, M.E.I.C.,*
*Chief of Aids to Navigation, Department of Transport, Ottawa.*

There is a convention governing every human enterprise. The convention in this case is that every discussion of lighthouse affairs begins with the Pharos at Alexandria, 280 B.C. But lighthouse engineering is older than that, as witness the excellent device which served to guide the Israelites on their memorable voyage across the Red Sea, 1491 B.C, namely the pillar of cloud by day, of fire by night. Between those dates there is no record of lighthouse engineering and little attention was given to the science for more than thirty centuries. Little definite progress was made until within the last two hundred years, and apart from lighting little was achieved prior to fifty years ago. In 1887 the lighthouse service had but recently emerged from the era of the tallow candle and the sperm-oil lamp; petroleum had come into general use only within the preceding ten years.

But lighthouse engineering is not singular in respect of rapid development in the last half century. Like every other forward step it has depended upon effective application of science in other directions, for example, in the petroleum industry, particularly the "cracking" of oil into gases; the unfolding knowledge of electricity; the evolution of the internal combustion engine; the rediscovery of Fortland cement; application of science to optics and acoustics; the contribution of chemistry in calcium carbide, acetylene, and acetone; vast progress in metallurgy; the miracle of radio.

### Lighthouse Towers

Important lighthouse towers, a hundred years ago, were built of stone and many of these fine structures are still in use. For the past thirty-five years all important towers have been built of reinforced concrete, some of the flying buttress type, as for example that at Cape Anguille, Newfoundland, shown in Fig. 1. The older light station at Cape Race is shown in Fig. 3. For lighthouse purposes concrete is a convenient medium for the reason that light stations are usually in isolated places, but sand, gravel, and water are generally available on the site and the proportion of skilled labour required is small. Waterproofing of old stone towers and recent concrete towers has presented a difficult problem, but is being solved by the use of plastic materials applied under pressure in the case of stone structures, and sealing compounds on concrete.

The distance lights can be seen is limited theoretically by the horizon, or the curve of the earth, and the distance of the horizon depends on the elevation of the observer. The higher the light the farther it can be seen. But as in every other art or undertaking many problems enter, with the result that it is convenient to adopt a mean or middle course. Lighthouse engineers are agreed that a first order light should have an elevation of one hundred and fifty feet above the sea.

### Foundation Piers

Suitable lighthouse sites are usually found on headlands or islands, but in many cases it has been necessary to build submarine foundations on shoals sometimes miles from shore. While no unsurmountable problems present themselves in this regard, construction work is rendered difficult on account of exposure to the sea, and the necessity of carrying on the work, especially in the earlier stages, by "tide work." At Brulé Bank, below Quebec, two such piers were built on pile foundations. As the name implies, the site consists of a sandy shoal and much difficulty was

**Fig. 1—Tower at Cape Anguille, Newfoundland.**

encountered during construction by scouring. The rise of tide is twenty-one feet and the current four knots at ebb and flood. The difficulty was overcome by the use of brush mattresses of special design.

South East Shoal offers another good example of this sort of construction, the foundation pier being built in twenty-one feet of water six miles south of the extremity of Pelee Point, Lake Erie. This structure also is on a sandy shoal, and consists of pile and crib foundation supporting reinforced concrete pier, power house, living quarters, and tower. It has withstood the full force of Lake Erie storm and ice these ten years, and shows no sign of movement or settlement. There is some slight scour, but that is corrected by stone rip rap.

### Optical Apparatus

Fifty years ago the Fresnel lens was in general use. The property of this optic was to gather the rays of light from the source into a horizontal focal plane, thereby greatly increasing the power of the light in the focal plane as compared with the source of light not so directed. In this case, three hundred and sixty degrees of horizon were illuminated, and, in order to make the light distinctive in character, various types of mechanism were used to revolve screens or shutters around the source of light and thereby give the character of one, two, three, or more flashes, or groups of flashes, the purpose being to enable the navigator to identify each light by the advertised characteristic of it. These Fresnel lenses were quite effective optically and of considerable size, built up of central lens belt and refracting prisms mounted in brass framing and measuring five or six feet in diameter and, possibly, eight feet in height.

A great advance was made thirty-five years ago by the adoption of an optic, then lately developed in France and England, which gathered the rays of light not only into the horizontal plane but into a vertical plane also, that is, the optical apparatus consisted of two or more faces, each face being of the nature of a very powerful searchlight. Appropriate clock work causes this optic to revolve, and, according to the angular arrangement of the faces, presents a characteristic to the navigator of one, two, three, or four flashes, or groups of flashes. Such an apparatus is shown in Figs. 5, 6 and 7. The largest of these modern optics is over eight feet in diameter, ten feet high, and the optic itself, that is the glass and gunmetal framing, weighs five

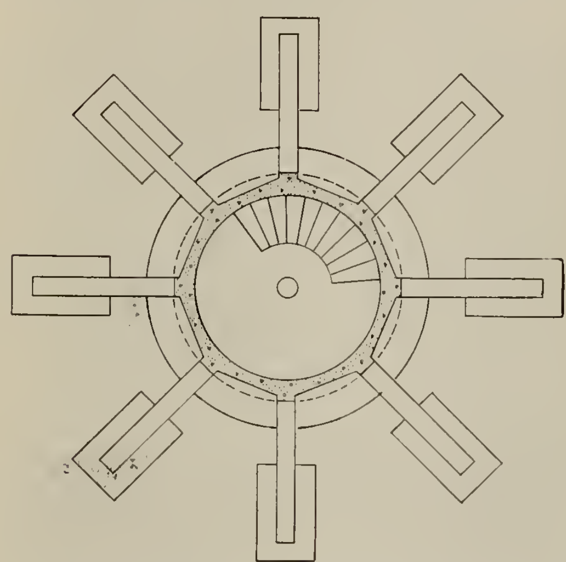


**Fig. 2—Plan of Tower at Cape Anguille.**

and one-half tons. In order to reduce friction and the effect of tower vibration, the optic is mounted on an annular cast-iron float which floats in an annular cast-iron bath of mercury. Although the weight floated, including the cast-iron float, is about seven tons, the quantity of mercury required is, by reason of the peculiar design of float and bath, only nine hundred and fifty pounds. The pedestal and clock weigh eleven tons, which, with the weight of the optic and lantern, makes a total load of forty-two tons on the top of the tower. The beam candle power is about four million candles. The cost of this lantern and optic when purchased in 1905 was $40,000.

The geographical range of a light depends on elevation above the sea, both of the light and of the bridge of the steamer from which it is observed. The light here described is one hundred and sixty-five feet above the sea, and the bridge of an ocean liner may be reckoned at sixty to ninety feet. On these factors the geographical range would be about twenty-five miles. The light has actually been seen seventy-six miles by reason of atmospheric refraction.

Extensive use is made of parabolic reflectors, particularly for range light purposes, but, on account of the flexibility, adaptability, and high candle power obtained from electricity, revolving reflectors are now being used in conjunction with electric lighting for principal coast stations.

In the matter of reflectors, a useful and interesting improvement was made some twenty-five years ago. For centuries, lighthouse reflectors were of the type commonly used for motor car headlights, the depth being large compared with the diameter. The distance of the focus of the parabola from the back of the reflector was relatively short. For example the focal distance of a twenty-four-inch diameter reflector would be only about three inches. It was consequently necessary to cut a hole above and below through which to pass the lamp burner and chimney. This seriously reduced the reflecting surface. Also it was necessary that each reflector should have its own source of light. In order to light the horizon it was necessary to revolve the reflector, the common practice being to mount three groups of reflectors disposed axially one hundred and twenty degrees apart, on a revolving mechanism driven by clock work. This gave the mariner the effect of a series of flashes, the interval between the flashes depending on the speed of the revolving system of reflectors. It was not uncommon to find five reflectors in a group or fifteen in the system, each of the fifteen equipped with its own source of light.

The late L. E. Coté, M.E.I.C., an engineer in the lighthouse service, and later chief engineer of the Marine Department, discovered that a relatively shallow reflector with relatively long focal distance would be equal optically to the age old deep type. A parabolic curve was adopted which placed the focus fifteen inches from the back of the reflector. While in the old type reflectors were circular, the new "long-focus" was made in the form of what might be described as a section of one-sixth of an orange peel as shown in Fig. 8. In width the section was made to subtend an angle of sixty degrees at the focus and the height of the section was thirty inches, the whole stiffened by ribs on the back—top, bottom, and sides. The reflectors were mounted on a revolving table, and, having a common focus, one source of light served all the reflectors of the system. By disposing these sixty degree segments axially sixty degrees apart and revolving the system, a single flashing light was obtained, the beam from each reflector passing through the opening opposite it between the other two segments. By placing the same three segments side by side a triple flashing light was produced, that is three quick flashes and a long interval between the groups.

**Fig. 3—Light Station at Cape Race, Newfoundland.**

Courtesy of Royal Canadian Air Force

**Fig. 4—Lighthouse, Point Atkinson, B.C.**

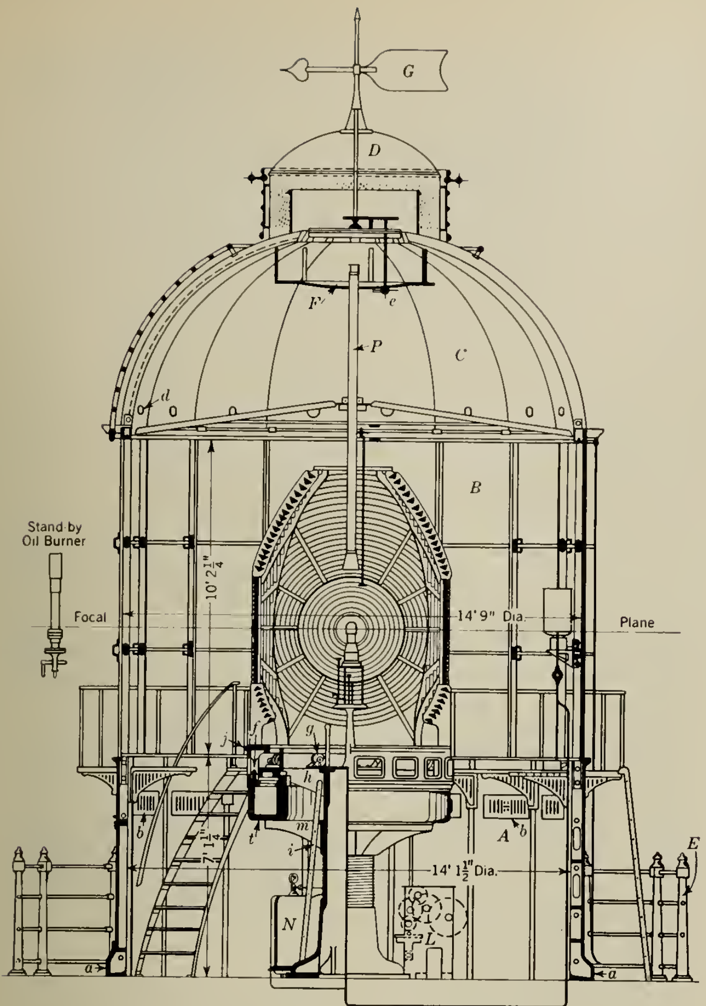



**Fig. 5—General Arrangement of Lighthouse Lantern.**

The double flash was obtained by adopting two segments subtending an angle of ninety degrees horizontally at the focus. In like manner the quadruple flash used four segments each subtending an angle of forty-five degrees.

A great advantage of this system is that by reason of the long focus, all portions of the source of light are approximately equally distant from all parts of the reflecting surface. The divergence is thereby greatly reduced and consequently a narrow beam of light is obtained, comparable to that of the cut glass lens and prism arrangement mentioned earlier. The reflector apparatus is inexpensive, costing only about six hundred dollars, compared with six thousand dollars for equivalent power in the case of a cut glass optic.

Another engineer in the lighthouse service, H. deMiffonis, M.E.I.C., latterly acting chief engineer of the Marine Department, now retired, also made an important departure in the use of reflectors. His contribution was to revolve a single deep short focus reflector, using electricity as driving power and source of light. The electric current to the lamp is interrupted by a system of contacts, which admits of producing any predetermined characteristic of light. A variation of his system is to use two deep short focus reflectors joined back to back with the apex of each cut away so as to admit of a common focus and a single source of light serving the two. Any characteristic may be had as in the case of the single reflector. This arrangement is powerful, flexible in respect of characteristic, and also inexpensive.

### Illuminants

Fifty years ago lighthouse illumination was confined to kerosene burned on a cotton wick, the Argand circular wick burner being then still in use. It was not until the early years of the present century that a notable improvement was made by the use of kerosene oil vapour burned under an incandescent mantle.

This improvement was made possible by the invention of the Welsbach mantle, which placed at the disposal of lighthouse authorities the means of producing a light of high intensity combined with compactness. The vapour burner consists essentially of means of vaporizing kerosene and burning the vapour under a mantle. The mantles vary in size, those in use being respectively 25 m.m. 35 m.m. 55 m.m., and 85 m.m., diameter, yielding respectively 250, 500, 750, and 1,000 candles. The size of the mantle to be adopted is governed generally by the focal length and design of the optic.

In the vapour burner, the vaporizing tube, one half inch to one inch diameter and eight to twelve inches long, is preheated by methylated spirits. When the tube acquires the correct temperature, the kerosene is admitted under thirty pounds air pressure and is vaporized. The vapour issues through a small aperture, part being led to the mantle and part directed against the vaporizing tube to maintain the vaporization temperature. Originally the tubes were made of seamless steel with 3½ per cent nickel content, and much trouble was encountered through rapid oxidation due to the high temperature. After persistent research, and test, an alloy tube of 18 per cent chromium has been evolved, with the notable result that whereas the earlier tubes would last only for a few nights, the chromium alloy is good for five to six months.

Some of the more important lighthouses are illuminated by electricity generated on the premises by internal combustion engine power. Commercial current where available and reasonably reliable is used. In all cases a specially designed electric lamp is used, the special features being that the filament is disposed as to arrangement or form to accord with the optical design of the lens. Also the filament is made in two halves in parallel so that in case of a filament failing the remaining half is still serviceable.

**Fig. 6—Optical Apparatus, Outside View.**

In the case of less important stations, the lightkeeper is not required to be in constant attendance, and so various devices are employed to guard against interruption. The commonest are warning bells which come into action on failure of current, and then the keeper puts in the standby emergency lamp. In cases where an interruption of even a minute or two would be dangerous to shipping, and this refers particularly to range lights leading through long, narrow, dredged, rock channels, interruption of light is provided against by the use of a battery, governed by a relay, which comes into action automatically immediately the current fails and supplies light until the regular current is re-established. These arrangements have regard to brief interruptions due to electrical disturbances in the atmosphere. Use also is made of time clocks to turn the current off by day.

Less important lights, particularly marking isolated rocks where daily attendance is not convenient, are lighted by gas stored according to one of the standard systems and burn continuously for predetermined periods commonly up to twelve months. In order to conserve gas, sunvalves are used to turn the gas off by day. These valves are actuated by sunlight and are very useful especially at points far distant from district headquarters and difficult from the point of view of replenishing the gas supply.

### Fog Signals

Fifty years ago fog signal stations were few in number, the instrument being either a cannon, gun cotton bombs, steam whistle, or compressed air trumpet. The cost of steam power, requiring transportation of coal to isolated points, difficult landings, and lack of sufficient fresh water, limited the establishment of mechanically operated sound signals. There was little or no progress until Mr. J. P. Northey, of Toronto, invented the diaphone about 1903. After some years of experiment and development the diaphone was adopted as the standard instrument, power being furnished by internal combustion engine to compress the necessary air. The power required depends on air consumption and this depends on the size of the diaphone and length and frequency of blast. Engines vary from six to thirty-five horse power.

The diaphone is shown in section in Fig. 9 and consists essentially of a piston reciprocating in a cylinder, in both of which are cut circumferential slots or ports. The piston is fitted with an operating head to which compressed air is admitted first on one side and then on the other, thus producing the reciprocating motion. As the ports in the piston pass and repass the corresponding ports in the cylinder, air at thirty pounds per square inch pressure is admitted, the speed of the piston being one hundred and eighty strokes per second, thus setting up one hundred and eighty vibrations per second in the atmosphere corresponding to the musical note F sharp in the tenor clef. The blast terminates in a quick descending note known as the grunt. This grunt is a very valuable distinctive feature and can sometimes be heard when the first part of the blast is inaudible. After years of observation and trial the diaphone has become the standard fog signal instrument throughout the world. Ordinarily the sound from the larger size of diaphone carries ten to twelve miles. Under favourable conditions it has been heard forty-five miles. Where shorter range is sufficient, smaller sizes of the diaphone are used and also electrically operated vibrators good up to six miles. The acetylene gun, too, is a useful instrument. Here acetylene is automatically mixed with air in suitable proportion, and exploded at predetermined intervals. (See Fig. 10.)

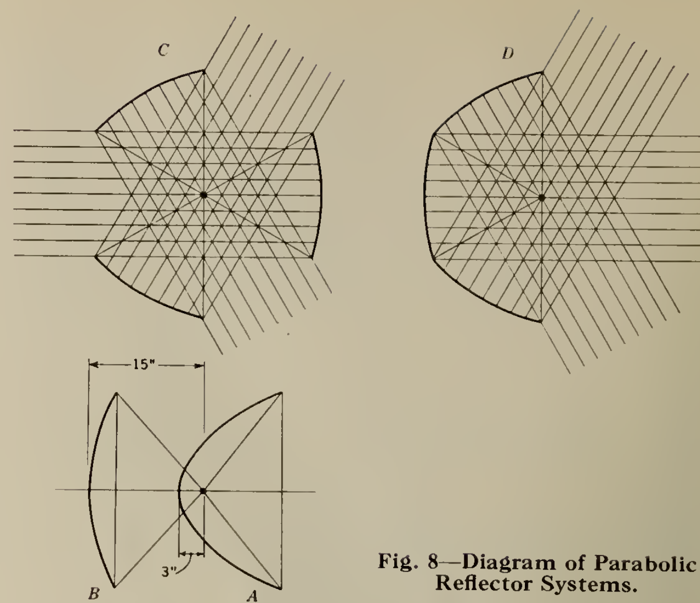


**Fig. 8—Diagram of Parabolic Reflector Systems.**

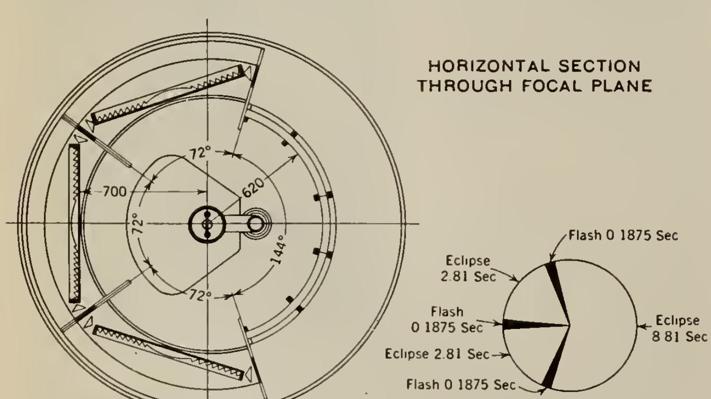


**Fig. 7—Section of Second Order Flashing Light.**

Air compressor equipment has passed through several stages in the last thirty years. In the early days use was made of the straight line compound steam engine with direct connected reciprocating compressor. Later separate engines and compressors were used with belt drive to accommodate the respective speeds, the kerosene engine being used for power purposes. Today advantage is being taken of the medium speed Diesel engine direct-connected to a rotary compressor.

It may be worthy of remark that loudness is not of paramount importance in the matter of the carrying quality of sound signals. Half a dozen riveting hammers, or a passing street car seem to fill the universe with sound, while in reality the sound is not heard a hundred yards away. A church bell of fine tone and consuming little energy may be heard for miles. Lying in a hotel in Halifax one can hear, through all the city noises, the pure musical note of the Chebucto Head diaphone nine miles away. Purity of tone is of first importance, strength of vibration or sound impulse next.

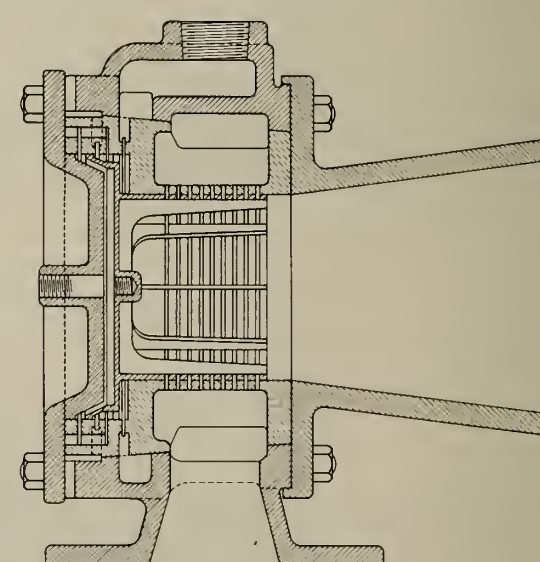


**Fig. 9—Diagram of Diaphone.**

Fig. 10—Automatic Acetylene Fog Signal Gun.

### Buoys

While bells of various sorts have been in use since the time of the worthy Abbot of Aberbrothock, and later whistling buoys, it was not until the nineties of the last century that gas buoys made their appearance. The first buoys operated on oil gas, known as Pintsch gas, stored in the buoy float under a pressure of ten atmospheres. The buoy lantern consisted essentially of a cut-glass lens, wind and waterproof housing and occulting mechanism whereby the flow of gas to the burner was interrupted for predetermined periods and relighted by a small pilot burning continuously. This arrangement served at once to conserve gas and to provide a light of distinctive characteristic. The disadvantage of this system lay in the relatively feeble light and necessity for frequent replenishing of gas.

With the advent of the manufacture of calcium carbide in commercial quantities, acetylene was seized upon as illuminant for gas buoys, the advantage being the relatively brilliant light and the possibility of storing a large quantity of gas, in the form of carbide, in a relatively small space. The smaller type of carbide buoy is eight feet in diameter and twenty feet over all. Within the float chamber is a carbide chamber holding one ton of carbide resting on a grating some three feet above the bottom of the chamber. A port in the bottom of the chamber admits sea water. When the buoy is placed in the water the air imprisoned in the carbide chamber prevents the water entering, or rather water enters only until equilibrium is established between the water pressure and the air pressure within the carbide chamber. When the valve in the lantern is opened the imprisoned air escapes, the sea water gradually rises in the carbide chamber until it reaches and attacks the carbide, immediately generating acetylene. The pressure set up by the acetylene thus generated forces the water out of the carbide chamber. As the gas is consumed the water gradually rises in the carbide chamber and the process is repeated over and over again. One charge of carbide is sufficient to operate a buoy of this type for twelve months. This type of buoy, in addition to being lighted, is commonly equipped with a bell which is operated by the motion of the buoy on the waves. Such a buoy is shown in Figs. 11 and 12.

The larger type of carbide buoy is eleven feet in diameter and fifty feet in length. This larger type of carbide buoy is always fitted with whistling tubes, two in number, twenty-six feet long, twenty-four inches in diameter. By the design of this buoy, of relatively small diameter compared with the length, the motion of the buoy in the sea is approximately vertical. As the buoy rises, air is drawn in through check valves; as the buoy falls, this air is expelled under water pressure through the whistle.

A later development in the use of acetylene is that whereby the acetylene is dissolved in acetone under one hundred and fifty pounds pressure. Acetone has the property of absorbing twenty-five times its own volume of acetylene per atmosphere pressure, with the result that relatively large quantities of acetylene can be stored in relatively small space. In this case also, the larger acetone buoys carry sufficient gas for twelve months burning.

Yet another type of gas buoy is the development of the original oil gas system which was made possible by liquefaction of oil gas. In this case the original buoys are used, but the gas is supplied in steel flasks under a pressure of fifteen hundred pounds to the square inch. The flasks are connected by hose to the buoy float and the gas is allowed to flow into the buoy to a pressure of ten atmospheres. A buoy so charged is good for three months.

Buoy moorings generally consist of close link chain, and granite, concrete, or cast-iron anchors. The chain varies from one inch to one and one-half inch stock, and the anchors from one to six tons depending on the size of the buoy and the exposure of the position to heavy seas. Some of these buoys are anchored in two hundred and fifty feet of water, the weight of chain and anchor approximating twelve tons, the weight of the buoy itself up to sixteen tons.

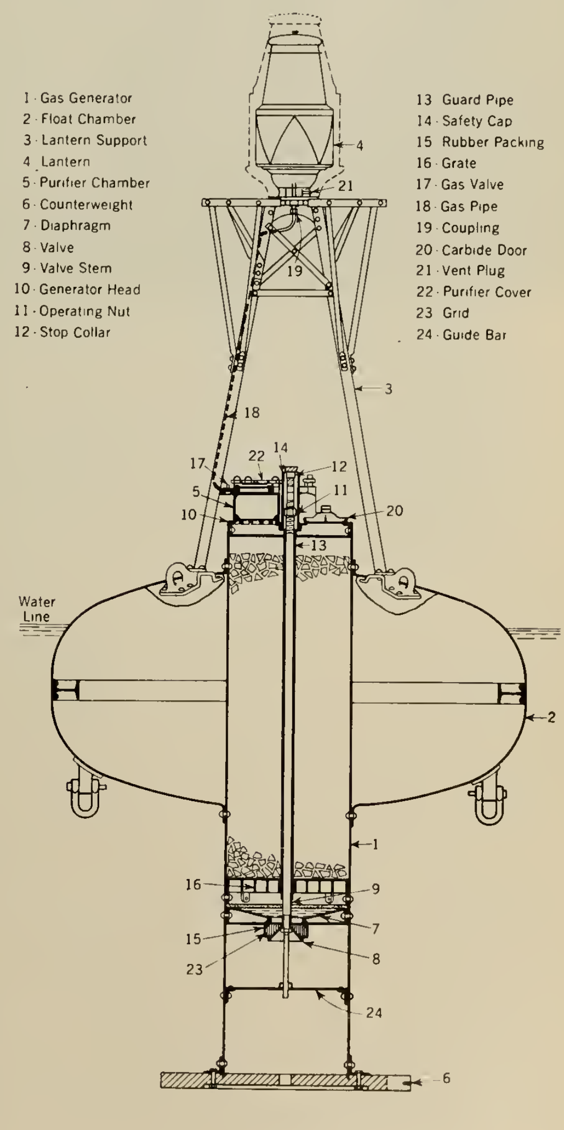



Fig. 11—Diagram of Gas Buoy.

### Lightships

Lightships, of which there are twelve in service, are seagoing vessels for the most part of the trawler type, but special design and construction is required in the case of lightships exposed to the open sea. The essential features of design are full lines of hull, high topsides, central hawsepipe opening at the water line and sufficient power to make head against the heaviest seas in order to relieve the strain which would otherwise come on the mooring cable. This design enables the vessel to surmount the seas, whereas, if built on finer lines, the seas would carry over her and tend to part the mooring, or carry away her upperworks. Lightships occupying ocean positions are equipped with light, fog signal and radio beacon. The first seagoing lightship was built and stationed in 1904.

Fig. 12—Handling Gas Buoy under Winter Conditions, Lake Erie.

### Radio Beacons

The most recently devised, and perhaps the most important, aids to navigation are the radio direction finding station and the radio beacon. In the case of the direction finding station a ship at sea, perhaps five hundred miles away, wants to determine its position. The captain sends a wireless message to a direction finding station asking what his bearing is. As the message is being received the operator at the station by turning a dial determines the bearing and replies immediately. The captain then sends the same message to another direction finding station and receives his bearing from that station. The two bearings intersect and thereby determine the position of the ship. In the case of a radio beacon, the apparatus is in continuous operation during fog and automatically sends out a signal at intervals of two to three minutes. In this case the ship is equipped with a mechanism whereby the bearing of the beacon may be determined. The captain takes radio bearings from two or more radio beacons and thereby determines his exact position. In fair weather the radio beacons send out signals for four or five minutes every hour, each beacon working on a definite time schedule. For example: the Halifax lightship fair weather signal begins one minute and thirty seconds past the hour; the Lurcher lightship in the Bay of Fundy begins four minutes and thirty seconds past the hour; and so on throughout the entire system.

A recent development is the combination of radio with aerial sound signals. The radio signal is synchronized with the diaphone sound signal. For practical purposes radio signals may be regarded as being received instantaneously. Sound travels through air at say 1,140 ft. per sec. Both the radio signal and the sound signal are emitted at the same instant. The radio signal is heard instantly, the sound signal several seconds later. The lag or elapsed time indicates the distance the navigator is away from the lightstation and the radio compass gives him the bearing. A lag of five seconds between the radio signal and the sound signal represents one statute mile. For example: if the lag is thirty seconds the distance off is six statute miles. This is correct within 10 per cent.

### General

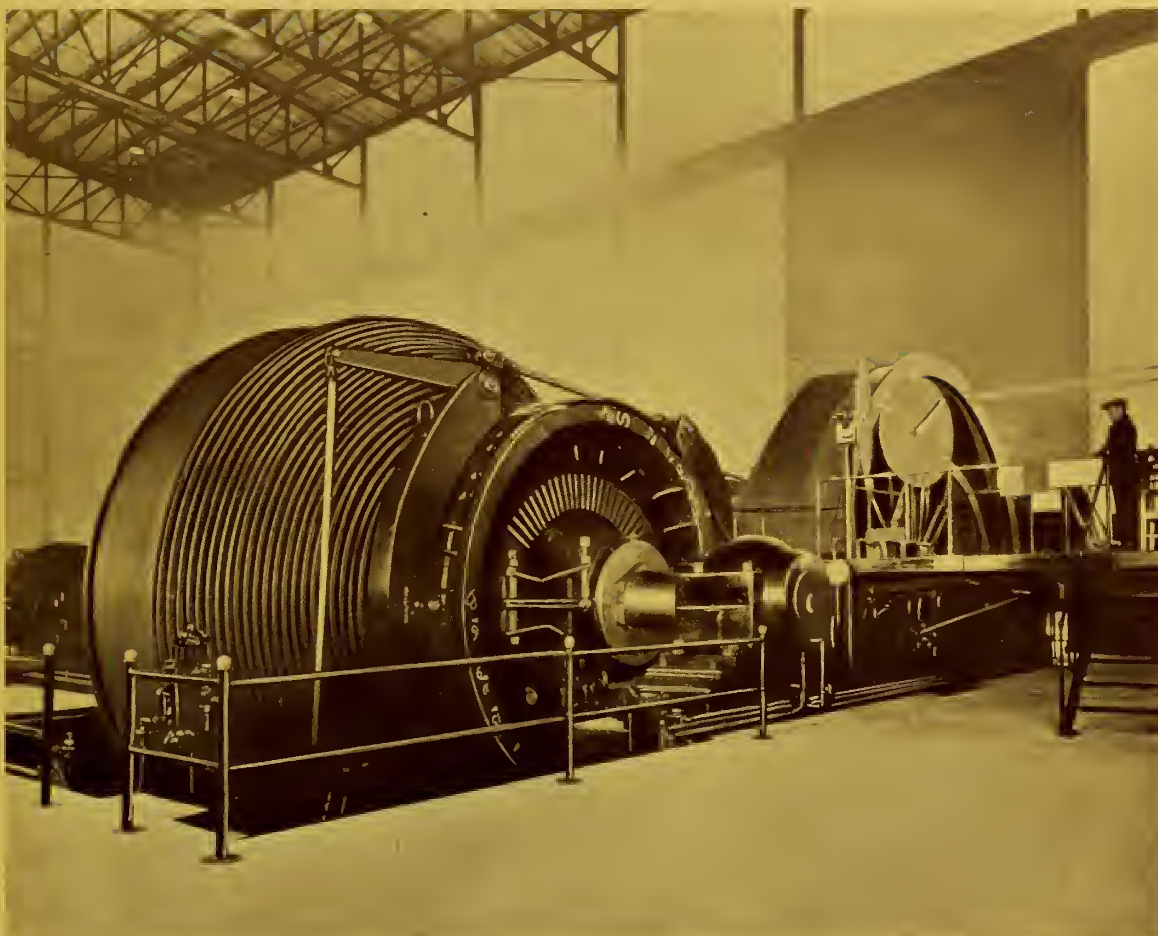
It will be apparent that lighthouse engineering is inseparable from lighthouse administration. The lighthouse service of Canada lies along many thousands of miles of coast and lake and river and has finally reached the Arctic ocean by way of the Mackenzie. The service consists, in round numbers, of 2,000 lights; 400 fog signals; 600 gas and signal buoys; 12 lightships; 9,000 unlighted buoys, beacons, and day marks; a total of 12,000 individual establishments. The staff numbers 2,500 persons.

The administration is constantly pressed to establish additional aids to navigation or to replace older equipment with new. Shipping interests in common with other classes demand the latest, not only in respect of necessities, but conveniences. Conditions, too, have changed. Ships are larger, of deeper draft and faster. The shoal that did not matter fifty years ago is a deadly menace to-day. Fifty years ago it did not matter much whether a vessel reached Montreal to-day or to-morrow or next week. In these times hours are a cause of concern. And so the lighthouse service is involved in the general competition.

The first problem of the lighthouse engineer is to determine what the requirements are in the matter of aids to navigation, then to determine how those requirements can best be met, having regard to the volume of traffic to be served, the dangers to be avoided, the probable consequences of shipwreck, whether loss of property only, or of life also, and the cost, both of the establishment and the annual maintenance of it.

A particular and unusual adaptation of aids to navigation, to suit particular requirements, has been made in Hudson Bay and Strait. The route is important and the season is short. Delay must, therefore, be minimized. While the vessels using the route are large, they are few in number. The Strait is well marked by radio direction finding stations and by a few small unattended gas lights. In ordinary circumstances a series of coast lightstations would have been established at intervals of thirty or forty miles along both sides of the five hundred and fifty mile Strait. Instead the Marine Department, looking back across the waste of more than thirty barren centuries, adapted the pillar of cloud by day, of fire by night idea, to provide a moving protective guide for voyagers.

The C.G.S. *N. B. McLean*, a powerful ice breaking steamer, occupies a stated position in the Strait. Her equipment includes lights, sound signals, radio, echo sounder, gyro compass, salvage pumps, hospital and surgeon. Last season a member of the crew of an inward bound vessel from France, suffering from acute appendicitis, was taken aboard the *McLean* and the necessary operation performed with complete success. The *McLean* supplies commercial vessels with radio bearings and information as to ice fields, and, if necessary, convoys them through the Strait—truly a pillar of cloud by day, of fire by night.



Canada's Largest Mine Hoist

Tandem conical, 25-foot double-drum, electric hoist, built at Rockfield Works, Lachine, Que., and installed at the Creighton Mine of the International Nickel Co. of Canada Ltd.

*Illustration through the Courtesy of the*
Canadian Allis-Chalmers Limited

# Mining Engineering

*W. G. McBride, M.E.I.C.,*
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During the period under review the production of metallic minerals in Canada has had a very large and fairly uniform growth. In 1887 the total value of metallic minerals produced was $2,073,746; by 1900 it had grown to $40,408,676; and in 1936 it reached the sum of $256,335,000. The increase in the price of gold accounted for $53,419,000 in the 1936 production, but low prices were received for all other metals except nickel. Even after deducting the extra value of gold due to increased price the ratio of 1936 production to that of 1937 is roughly 100 to 1. It is notable that in 1887 no nickel or zinc was produced in Canada.

The great wealth of metallic minerals which is being developed in Canada lies in the pre-Cambrian or oldest rock formations. In these ancient rocks mineral deposits are not only frequently found, but are remarkably persistent and give long life to the mines which operate them. This is not only true in Canada but in other parts of the world where rocks of this age occur. Metallic deposits in the younger formations are frequently shallow and are rapidly worked out. Fifty years ago most of our metal mines were in the younger formations and consequently were short lived. Today the developments are coming largely in the pre-Cambrian and many of them have already been proved to great depth, and there is decided evidence that in many mining districts the limit of depth to which the mines may be carried will be the ability of our engineers to meet the problems of increasing rock pressure and temperature involved in deep mining. This is a most important and encouraging development and must be given due consideration in any attempt to evaluate the mineral development of our country. This Canadian Shield, as it is commonly called, occupies about two-thirds of our country. Most of it is remote from existing transportation facilities and it is difficult to prospect. But new and important mines are being brought in every year, and it will take many generations to develop it fully.

### Mining and Metallurgical Education

Fifty years ago engineers and geologists played a very small part in mining, probably as great as they deserved. Their knowledge and training were insufficient and when it came to management they had difficulty in competing with the practical man. Economic geology was in its swaddling clothes and geologists were chiefly interested in mineralogy, petrography and stratigraphy. Mining engineers were largely surveyors, assayers or draftsmen. Neither knew much about the genesis of ores or the rock alterations accompanying mineralization. Mineral discovery was almost entirely a matter of chance, while mining and reduction of the ore was quite unscientific and largely governed by rule of thumb.

### Transportation

Transportation may seem foreign to this article, but it has such a profound effect on the development of the industry and is in so many cases a problem for the mining engineer who has to provide his own transportation facilities that it cannot be omitted. Even yet the greater part of the Canadian Shield is not served by railways nor highways. Falls and rapids interrupt water transportation and the distances by water are sometimes great. Bush and swamp make the use of pack animals impossible. The Canadian miner must improvise transportation facilities to suit his conditions. His greatest aid is the aeroplane. Planes equipped with pontoons in summer and skis in winter give rapid and safe transportation of men, mail, food and light supplies at reasonable costs, and in emergencies they are used for machinery and heavy supplies. Where possible, other means are used for heavy haulage and the plane for auxiliary service.

Where rapids or falls interrupt water haulage the so-called marine railroad is used to haul barges from one level to another, thus avoiding the necessity of two transfers. The rails are run into the water at each end and the barges are floated onto cars which have been submerged on the tracks. At the other end the process is reversed. Haulage is by cable and hoist, so that heavy grades may be used. By this means supplies for the Red lake area are transported one hundred and ninety miles from the railway, at a cost of $20.00 per ton, or 10.5 cents per ton-mile. The outboard motor has speeded up canoes and other small boats to a point which makes them very useful for prospecting and light haulage.

Where railroads are distant and water communication impossible, winter roads are cheaply constructed by cutting out the trees and cutting down steep grades. Rivers and lakes offer no difficulties and in most cases are a great help. Haulage is done on sleighs pulled by caterpillar tractors. These beat down the snow as it falls, and occasional dragging to fill up chuck holes is all that is required in the way of maintenance. On rare occasions shovelling may have to be resorted to. On long hauls tractors run night and day. In some cases one sleigh is equipped with kitchen and sleeping quarters; a cook prepares meals for the drivers, who take turns at the controls. Costs vary widely, but will run somewhere between 15 and 25 cents per ton-mile. Where there is uninterrupted water haulage from railhead costs are very much lower. Even with these moderately high costs, gold, silver and radium mines may be operated at long distances from railroad or ocean transport.

### Prospecting

Constant and active search for new mineral deposits is essential to replace worked-out mines and to provide for expansion of the industry. The art of prospecting has made many important advances and a technique has been developed to meet the conditions in our north country, which are different in many respects from those existing in other countries. The element of chance has been greatly reduced by the application of sound scientific principles. Rumours started by Indians, trappers and other travellers in the north country still play a part, but a much less important one than formerly. The prospector, partly from association with engineers and geologists of the mining companies and partly from schools for prospectors conducted by some of the provinces, has learned something of minerals, rocks and geological formations and is able to read a geological map sufficiently well to be able to pick out the areas which present conditions favourable to mineralization. The Geological Survey of Canada and the geological departments of several provinces lend invaluable aid by preparing, each year, geological maps of areas which have previously not been mapped in detail. From the air geological conditions can be recognized, in some cases, in a way and with a speed that is impossible from the ground. The air view of Outpost Islands shown in Fig. 1. illustrates this admirably. It can readily be seen that these islands are the upturned edges of steeply pitching sediments and that there is a decided bend in the strike of the beds. The only other probable explanation is a great zone of brecciation due to rock movements. In either case it is obviously a good place to search for mineral. The aeroplane is also serving a very wonderful function in quickly placing or moving prospecting parties, supervising their work and keeping them in supplies. The speed at which modern prospecting in Canada is done offers an amazing contrast with the slow progress of half a century ago.

Where outcrops are few and the country is largely covered with water, muskeg or wet soil, geophysical surveys offer a very important aid in tracing out concealed parts of the ore bodies, in discovering related but totally concealed ore bodies or in tracing out faults, shear zones or contacts with which the mineralization is associated. For metallic minerals the electrical and magnetic methods have been found the most helpful. These geophysical surveys are not positive but are, when intelligently used, a great help to the geologist and engineer in deciding on where and how to attempt further work to prospect beyond the definite showings of mineral. Diamond drilling has been perfected to a point where it gives a very useful method of cheaply proving up geological conditions under water or other overburden. In some cases it gives a fair idea of the size and grade of an ore body, but diamond drill results should be regarded as indicative rather than positive.

### Mining

There has been improvement all along the line in mining. Each mine is a problem in itself and it is difficult to reduce mining to a definitely scientific basis, but progress is being made and in some cases it is quite revolutionary. Standardization has helped in some things but in others the progress has come from breaking away from accepted practice and developing new methods based on a study of the conditions peculiar to the mine. It is impossible to even mention all the improvements that have been brought about as a result of engineering study, in the period under review, but a few of the outstanding developments are listed. Electrification of all machinery, except for drilling rock, and electric lighting have greatly reduced general power costs and improved operating conditions. Improvement in the development, distribution and use of compressed air, in the placing of holes, in the strength and distribution of explosives and the speed of detonation have greatly speeded up development and reduced the cost of breaking rock or ore. Improvements in ventilation have permitted mining to greater depths, and have made working conditions safer, more pleasant and conducive to greater output. Increased knowledge and use of economic geology have greatly reduced the number of failures in prospecting and the amount of development work necessary to prove up and prepare the ore for mining. Geological study has also greatly assisted in working out more economical methods of stoping the ore. Mechanical means of loading and transporting the broken rock and the self-dumping skip for hoisting have cheapened and speeded up the handling of broken rock. Larger scale of operation has reduced overhead, made possible greater capital outlay in labour-saving machinery and made possible many improvements to promote the safety and welfare of the workmen.

In stoping, successful efforts have been made to reduce the amount of timber necessary to support the ore and walls,

Courtesy of Royal Canadian Air Force.

**Fig. 1—Air View of the Outpost Islands.**

to secure as complete extraction of the ore as conditions will permit, to reduce dilution of the ore by low grade or barren material, to provide mechanical aids to the miner and to make use of gravity as an aid to handle the broken ore and even to break it. It is in these uses of gravity that the greatest strides have been made. In the rill method the operations are so arranged that the ore, when broken, flows down an incline to a chute, where it is guided into a car. Similarly, barren material is brought into the stope by gravity to fill the place formerly occupied by the ore. Shovelling of ore and fill is thus eliminated.

Perhaps the most revolutionary method is the "block caving" used at the King mine of the Asbestos Corporation; an isometric sketch of this is shown in Fig.2. As will be noted the ore is mined in large blocks. Suitable raises are provided to conduct the ore from the stope to a "grizzly" or grating, where the oversize boulders may be broken by hand hammers or blasting. Material passing through the grizzly flows down inclined raises to the haulage level for loading into cars. A section of ore, a few feet high, is broken out on the "undercut level" over the entire area of the block. As this is drawn down and support removed, the overlying ore breaks of its own weight, or "caves." Control of the drawing at the raises above the grizzly level makes it possible to cause this caving to occur at a fairly uniform rate over the stope section and it is held within pre-determined lines by weakening the boundaries of the stope by drives at vertical intervals around the stope. The amount of blasting necessary at the grizzlies varies with the nature of the ore but is comparatively small, as the ore is not only subject to tension strains due to its own weight, but to the shattering of its own fall and the fall of other boulders. It will be observed that not only does this method eliminate

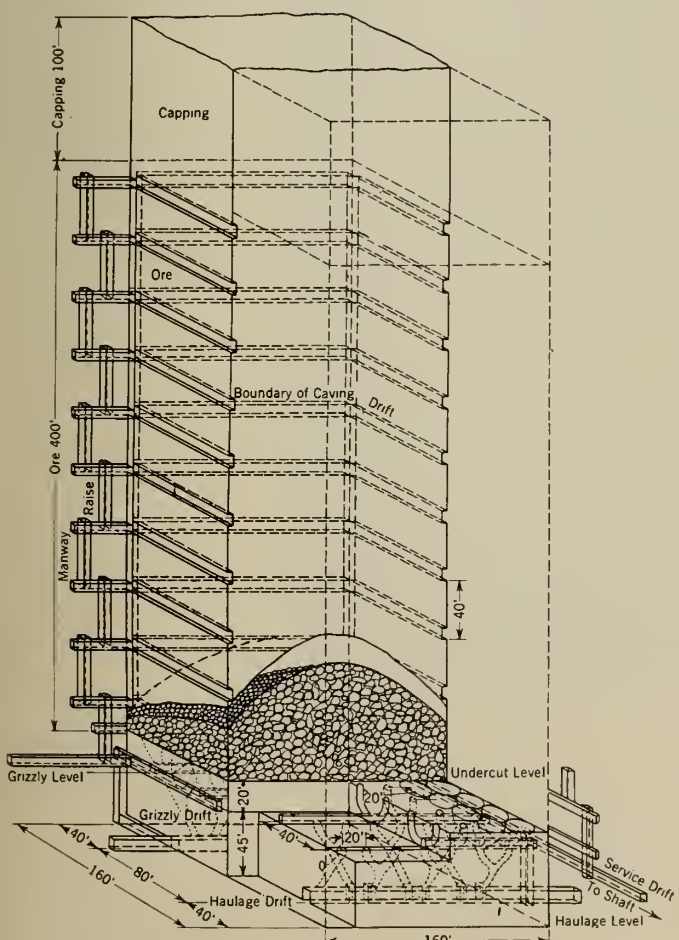


Fig. 2—Isometric Drawing of Stope Block, 160 ft. by 160 ft.

shovelling but that a large proportion of the ore does not have to be blasted but is broken by gravity. Mining by this method is very cheap, its only disadvantage being that some ore is mixed with the overlying waste and must either be left behind or is diluted.

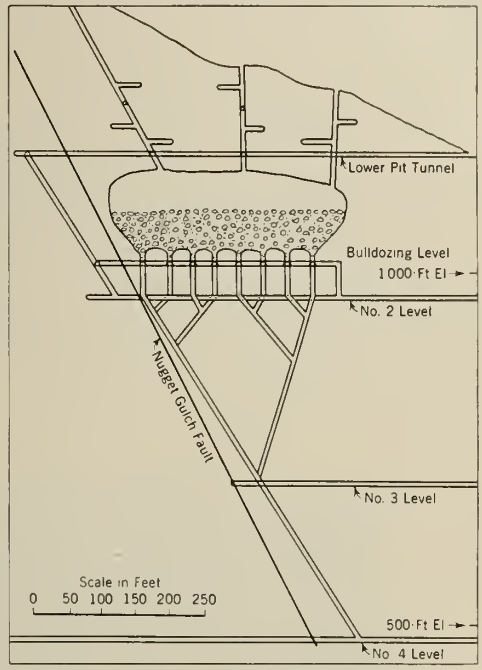


Fig. 3—Longitudinal Section Through Stope at Alaska Juneau Mine.

Figure 3 shows the method used at the Alaska Juneau mine, where the ore is more resistant to caving. In this, raises are driven into the ore and caving is assisted, where necessary, by large charges of dynamite placed in short drifts from these raises. Similar methods are used at the Britannia mine.

In still stronger ore the sub-level and spiral raise methods have been evolved to secure large scale production and efficient use of explosives. In these, gravity does not play such an important part in breaking the ore but it does away with shovelling and stope tramming.

Although there has been a remarkable development of new stoping methods the square set, the stulled stope, the shrinkage stope and the underhand open stope still survive and each has its field of usefulness. They have been greatly improved, however, and are used only for the particular cases where conditions make newer methods inadvisable or to supplement newer methods.

### Concentration and Milling

In concentration, smelting and refining, engineering advances have been quite revolutionary. The cyanide process has increased the recovery of gold from the 60 to 85 per cent formerly made, to from 90 to 99 per cent. Moreover, the process has been made continuous, almost automatic and consequently cheap. Flotation has almost entirely replaced gravity methods for the concentration of sulphide minerals and is also extensively used on non-metallic minerals and native metals. It gives a more complete recovery, a higher grade concentrate and lower cost than any other method. The flow sheet of a flotation mill is remarkably simple, the space occupied per ton of capacity is low and the amount of labour and power required is small. But by far the most important feature of this truly remarkable process, is that it can be made selective, that is, one mineral at a time can be floated away from the gangue and from valuable minerals of like specific gravity and other physical characteristics. This makes it possible to treat complex ores which were valueless to the miner of twenty-five years ago. For example, the great Sullivan mine at Kimberley was of no commercial value until selective flotation was developed. Its ore is a complex mixture of sulphides of lead, zinc and iron. In the smelter no two of these elements could be saved simultaneously, and in fact two of them were always detrimental to the extraction of the third. With selective flotation the lead sulphides are first floated out of the ore, which has been ground in water to a fine ground pulp; then the zinc sulphide ground in water to a fine pulp; then the zinc sulphide is separated from the residue and the iron sulphide allowed to accumulate as "tailing" until such time as there is a demand for it. As many as six different products may be made from one ore by selective flotation.

In the mechanics of milling there have also been important changes in methods of crushing, grinding, classification, handling, sampling, dewatering and drying, but these have had a less profound effect than the introduction of cyanidation and flotation.

### Smelting

In smelting perhaps the most important innovations have been the introduction of the converter, the sintering machine, the electric dust precipitator and the continuous roaster. Blast furnaces have been greatly improved and the reverberatory furnace revolutionized. The improvements in smelting have been great, but have been largely in perfecting details rather than in the introduction of metallurgical processes based on new basic principles.

### Refining

Refining or purifying the metals has gone ahead, but like smelting the changes have been largely in improvements in processes or their adaptation to new uses. Electrolytic refining has been adapted to lead, zinc and other minerals. Greater attention has been paid to purity of product and to by-products. The copper, lead and zinc refineries are producing important amounts of cadmium, selenium, tellurium and many of the rarer metals.

Fundamentally, the greatest forward step that has been made in milling, smelting and refining during the past fifty years is the study of the basic scientific principles and reactions involved. This has led not only to the discovery of new methods but to improvement in details and more accurate technical control of operations, with consequent improvement in results. Formerly, operating control was almost entirely based on the judgment of an experienced operator; today it is pre-determined by calculation or is based on the results of frequent tests, using sound scientific methods.

### Conclusion

The results of this improvement in engineering practice in mining and treatment of ores have been an improved product, lowered cost of production and, most important of all, increase of output and future reserves through obtaining a more complete extraction and bringing into the profitable class many ore bodies which, due to low grade or complex mineralization, were valueless under the old methods. Without the cyanide process few Canadian gold mines could produce profitably, despite the higher price for gold, and none could maintain the present scale of operations. Without flotation the Sullivan, Flin Flon, Britannia, Sterling and many other important mines would never have been profitable.

It is interesting to note that the cyanide process was patented in 1887 and its first commercial application made in 1889. The first patent bearing on flotation was granted in 1860, but it was not until 1902 that patents were granted for the use of gas as a buoyant medium for the flotation of heavy minerals. In 1913 came the first recognition of selective flotation, and its first application in Canada came in 1920 in a pilot plant at Trail, B.C. The first successful commercial application of flotation to the treatment of complex ores in Canada was at the Chapman concentrator of Consolidated Mining and Smelting Company in 1923.

AERIAL photograph of Mercier Storage Dam on the Gatineau River, Province of Quebec. This dam was constructed in 1926-27 by The Foundation Company of Canada Limited for the Quebec Streams Commission and the Gatineau Power Company. The building of this dam created one of the largest storage reservoirs in the world, its capacity being approximately one hundred billion cubic feet of water.

*Illustration through the Courtesy of*
THE FOUNDATION COMPANY OF CANADA LIMITED

# Irrigation Engineering

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Early explorations and surveys in Western Canada, almost without exception, referred to a large area in the southern portion of what is now the provinces of Saskatchewan and Alberta as an arid or semi-arid belt. Its boundaries naturally varied according to the nature of the seasons in which the observations were made, but the average content may be defined as that portion of the provinces of Saskatchewan and Alberta lying south of a line running northwesterly through North Portal, Weyburn, Moose Jaw and Rosetown to a point on the Saskatchewan-Alberta interprovincial boundary near Macklin, 240 miles north of the International Boundary, thence southwesterly towards the foothills of the Rockies, say 40 miles northeast of Calgary, thence straight south through Macleod to the International Boundary—the area containing between 40 and 50 million acres. It is a part of the Great Plains area which stretches all the way from the Mackenzie Basin to central Texas, all of which is an area of low average rainfall. It is also known as "the shortgrass country" and corresponds closely with what has been termed the Drought Area of the past few years. It possesses two of the essential elements for successful agriculture—good soil and abundant sunshine—but is lacking in the third essential—moisture.

It is not arid in the sense of being barren and unproductive. Until broken by the plough it produces good range grass, and in all except the driest portions has periods of good grain crops, alternating with periods of drought.

The completion of the Canadian Pacific Railway across the prairies in the early eighties was followed by the westward movement of settlers. As settlement increased and spread farther and farther westward, the necessity and the possibilities of irrigation on these fertile plains between Moose Jaw and the mountains did not escape the attention of railway and government officials and engineers. This interest increased to such an extent that in 1893 an act was introduced in the Dominion Parliament dealing with the matter. The act was not passed at that session, but J. S. Dennis, Chief Inspector of Surveys, was commissioned to visit the western United States for the purpose of studying and reporting on the irrigation laws and practice in that country. His report was submitted to Parliament at its next session, and upon the recommendations contained in it, was founded the Northwest Irrigation act passed by Parliament July 23rd, 1894. This act has been the legal basis of all subsequent irrigation legislation and development in Canada, and was recognized by authorities in the United States as being much superior to their irrigation laws at that time.

**Fig. 1—Truss Bridge Carrying Inverted Siphon across Okanagan River.**

In speaking of the developments which led up to this result, Mr. Dennis in his report to the Government on irrigation in 1894, said, "The existing climatic conditions, and the necessity for irrigation, have been frequently referred to in the reports of Dominion Land Surveyors employed in surveying this arid region into townships and sections, but it is probably due to the lengthy reports upon this subject and to the persistent advocacy of the principle by Mr. William Pearce, Superintendent of Mines, more than to any other cause, that the public has at last recognized the necessity for irrigation and the benefits to be secured therefrom."

The necessity and advantages of irrigation were given first official recognition by Mr. Pearce in his report for 1885. Mr. Dennis also mentions it in his report for 1886. The Deputy Minister, in his report for 1885, says, "Mr. Pearce raises what is practically a new question when he discusses the irrigation of comparatively dry tracts in the grazing country," and comments that "it will be a long time . . . before . . . settlement . . . will reach the class of country to which Mr. Pearce's suggestions relate." But these two men continued to raise the question and it was not so long after all before it was a live and practical issue. These men were responsible in large measure for the development of irrigation in western Canada during the next thirty years.

The year 1894 therefore may be taken as marking the beginning of any definite government policy in the matter of irrigation. In that year the Northwest Irrigation act became law, and the Dominion Government began its general irrigation surveys under the direction of J. S. Dennis. In his report for that year he presents a list of ninety-three canals in operation, under construction, or projected in that portion of Alberta and Assiniboia known at that time as the "Arid Region." These were all for small areas with the exception of the Calgary Irrigation Company, the Alberta Irrigation Company, and the Springbank Irrigation Company, and only the first one of these three had at that time started construction. Sixty-three projects are shown as being constructed and in operation in 1894, ranging in area irrigated from seven acres to 2,500 acres.

In May of the following year an Irrigation Office was established in Calgary by the Department of the Interior of the Dominion Government, in charge of J. S. Dennis, for the administration of the Northwest Irrigation Act.

The foregoing refers entirely to the country east of the Rockies, but before proceeding with the details of the development of irrigation on the prairies, a brief reference should be made to still earlier work which was going on west of the Rockies where the administration of land and other resources was under the control of the provincial government.

## IRRIGATION IN BRITISH COLUMBIA

The first record of an application for the right to use water for irrigation in Canada was in 1858 when British Columbia was still a Crown colony. This was for the use of water from Nohomeen creek near Lytton and is recorded in the official records dated at Fort Yale October 30th, 1858, in the name of George K. MacCulloch. Likewise, the first act in Canada providing for the acquisition of a water right and for the issuing of rules and regulations governing the use of water was proclaimed in British Columbia by Governor Douglas in 1859 and known as the

"Goldfields Act." While this act was apparently intended to apply primarily to the diversion and use of water for gold mining, a number of applications for water for irrigation were dealt with under it, until in 1865 the Land Ordinance was enacted which provided more definitely for the requirements of irrigation.

### The Doctrine of Beneficial Use

An important feature of the Goldfields Act of 1859 was the provision that the applicant for a water right was entitled only to the amount of water which he put to beneficial use, the surplus being forfeited to the Crown and becoming available for grant to another applicant. Thus was established at this early date an important principle which has been recognized in all subsequent irrigation legislation in Canada—the doctrine of beneficial use.

Another provision of significance and importance was contained in the Water Privileges Act of 1892. That was the declaration that the right to the use of all water not at that time recorded and appropriated was vested in the Crown in the right of the province. This likewise is the underlying principle of the Irrigation Act passed by the Dominion Government two years later.

### Riparian Rights

The old English common law doctrine of riparian rights gave to the owners of land abutting on streams the right to use the water of the stream for domestic or milling purposes, but any water diverted from the stream must be returned to it undiminished in quantity and unpolluted in quality. As irrigation developed on this continent it became evident that its requirements were in direct conflict with this doctrine, for when water was diverted for irrigation it could not be returned to the stream.

In the early development of irrigation in the Western United States water rights were acquired by posting notices at or near the source of supply, like the old system of posting mineral claims. They were often extravagant, inaccurate and overlapping in their claims—in some cases ten or even twenty times the flow of the stream being claimed by rival interests. Complications, confusion and litigation necessarily followed, and it was not an uncommon experience for the cost of litigation establishing the legality of a water right to exceed the cost of the construction of the system.

Canadians had the opportunity of observing the confusion which existed in the early stages of the development of irrigation in the United States and were wise enough to profit by their experience and mistakes. The benefit of these observations is reflected in the provisions of the Water Privileges Act of British Columbia and the Northwest Irrigation Act of the Dominion Parliament. The fact that practically no litigation has grown out of the establishing of water rights under these acts is evidence of the wisdom of their underlying principles.

### Difficulties Encountered

The topography of British Columbia prevents the irrigation of any large areas such as are found on the prairies. The valleys as a rule are narrow. Where they expand into broader stretches, they are frequently covered by lakes or are subject to flooding. The bench lands suitable for irrigation are too high above the main streams to be served by gravity and the cost of pumping as a rule is prohibitive. This makes them dependent for water supply on the small lateral streams, which because of the rugged topography and steep slopes have a rapid runoff. Consequently only a small percentage of their total flow can be utilized unless storage can be provided to supplement the period of low flow. Again, the topography is unfavourable because suitable sites for storage usually exist only near the heads of the streams at points where the catchment areas above them are too small to be of great value.

These natural features add immensely to the problems of irrigation development in British Columbia, but in spite of them the pioneers and engineers accomplished much.

In the early stages of irrigation development in any pioneer country, it is natural and necessary that the first efforts are confined to small individual schemes bordering immediately on the streams, where diversions can be made easily and at little cost. Next come partnership or small community enterprises where neighbours combine their resources. These types have usually served their purpose successfully, because their cost of construction and of operation was low and they had a priority of right to the water supply.

The next step in development was usually a more pretentious one, undertaken by individuals or companies who acquired ownership of large areas of land and built irrigation works to serve them, expecting to reap a profit on the sale of the land with water rights. These enterprises, large or small, have nearly always ended in financial disaster. Many factors have contributed to these results. Among them may be mentioned—(1) Insufficient knowledge of the sources of water supply and its seasonal variations in flow; (2) An under-estimate of the time and cost of placing settlers on the land and bringing it into profitable production. A large part of the cost of operating the system during this period must be borne by the promoters—in fact, the whole proportion chargeable to the unsold area, and frequently a large proportion on the sold area because of inability of the new settlers to meet their payments; (3) For like reason, the inability to dispose of their lands quickly and reimburse themselves for the cost of the enterprise often finds the promoters still carrying the burden when heavy repairs and renewals become necessary. Their cost is frequently beyond the financial ability of either the promoter or the settlers, and disaster results.

### Development in the Okanagan Valley

While irrigation is practised in many valleys in the interior of British Columbia, its most extensive development has been in the Okanagan Valley. The first water right recorded in the valley was by Charles A. Vernon, on Coldstream creek, in 1868. In 1872, William Smithson took out a water right on Mission creek, and in 1874 Andrew Brown filed on Mill creek, both near Kelowna.

The first venture in what has been described in a previous paragraph as the second step in irrigation development, was made by Lord Aberdeen, when in 1891 he purchased the Coldstream ranch near Vernon, constructed an irrigation system, and offered it for sale in 1893 in small tracts as irrigated orchard land. This was followed during the first decade of the present century by the construction of many irrigation systems throughout the valley to serve areas which were subdivided and put on the market, usually as five and ten acre orchard lots, to meet the boom demand for fruit lands.

### Co-operative Enterprises and Government Assistance

The fruit land boom collapsed just prior to the Great War and these projects entered the period of financial difficulties. The struggle for existence which followed led to the formation of co-operative organizations for operating the irrigation works. The legislative machinery at first was inadequate to deal with the situation, but gradually there was evolved the principle of ownership and operation by the water users themselves through the medium of Irrigation Districts. This evolution in legislation as well as in operation has been the outstanding feature of irrigation development since 1920.

The problem was a difficult one. Irrigation structures had deteriorated, the companies which had built them were bankrupt, inadequate and unprofitable market outlets for fruit and other produce made it impossible for the farmers themselves to meet the necessary costs of rehabilitation and continued operation. Under the stress of such conditions it was necessary to appeal to the Government for financial assistance, and as a result the province has since 1918 loaned more than three and a half million dollars to Irrigation Districts.

But there are compensating factors. Thousands of people have built up homes on these projects and have produced millions of dollars of agricultural wealth. It is to be hoped that better markets and general improvement in conditions will soon restore these potentially wealthy districts to a position of economic independence.

#### South Okanagan Project

Before leaving the province of British Columbia mention should be made of one project which differs in many characteristics from the typical ones already referred to. This is the South Okanagan project at Oliver, developed by the provincial government in 1919-1920.

It has been stated that most of the irrigated land in British Columbia is in small broken areas, too high above the main streams to be served by gravity ditches from them. The South Okanagan project is one exception. It covers an open valley about 25 miles long, lying between the outlet of Okanagan lake and the International Boundary. A concrete dam diverts the water from the Okanagan river at a point two miles below Vaseau lake. The canal is concrete lined for a distance of about seven miles and has a capacity of 170 c.f.s. An inverted syphon 3,578 ft. long of 80-in. steel and 78-in. wood stave construction crosses the Okanagan river to the west side of the valley. Many flumes of wood stave and of metal construction are required for side hills and ravine crossings. Pumping plants at three points serve lands above the main canal. Engineering work was done by the provincial government staff and was of a high order throughout. (See Figs. 1, 2 and 3.)

### IRRIGATION ON THE PRAIRIES

The earliest use of water for irrigation in Alberta of which there is any record was by John Glen, who in 1879 built a small ditch out of Fish creek, eight miles south of the present city of Calgary, and irrigated fifteen acres in section 3, township 23, range 1, west of the 5th meridian, with "satisfactory results." Prior to this a ditch had been started from Beaver creek and carried down the flat on the north bank of the Oldman river in what is now the Peigan Indian Reserve. This ditch was started by two Americans who came in with a band of horses and settled there, but before they had it completed, the land they intended to irrigate was set apart as an Indian Reserve, so they abandoned their enterprise and returned south. As the treaty under which the Peigan Indian Reserve was set apart was concluded on September 22nd, 1877, it must have been in that year that the ditch was built. During the next fifteen years there was more or less activity, chiefly among ranchers in the construction of small irrigation works, mainly for the irrigation of hay meadows.

The next event was the passing of the Irrigation Act and the beginning of general irrigation surveys by the Dominion Government under J. S. Dennis in 1894. These surveys indicated the feasibility of irrigating large areas in southern Alberta east of the foothills of the Rockies, and it is proposed to follow briefly the history of the development of some of these schemes.

The first authorization by Act of Parliament for irrigation in Canada was given when the Macleod Irrigation Company received its charter in 1891. The main object of the company was to secure the unoccupied available land in eight townships around Macleod, namely, township 8, ranges 25 and 26; township 9, ranges 23, 24, 25 and 26, and township 10, ranges 24 and 25, west of the 4th meridian, with a view of putting whatever area was susceptible of irrigation under water. The project was examined and reported on jointly by J. S. Dennis, then Chief Inspector of Surveys, and William Pearce, D.L.S., who recommended the sale at one dollar per acre under certain regulations regarding the construction of irrigation works. No construction was undertaken, however, and in January 1896, G. A. Kennedy, secretary of the company, was advised by the secretary of the Department of the Interior that the time for commencement of the works had lapsed and that the matter of reservation of the lands would be held in abeyance until such time as the company again approached the department.

In 1892 the High River and Sheep Creek Irrigation Company was incorporated, but no construction was ever undertaken. In 1893 three charters were granted—The Alberta Irrigation Company, the Calgary Irrigation Company, and the Calgary Hydraulic Company. The first of these was an outgrowth of plans of Mormon settlers to acquire and colonize a large area in southern Alberta. Their application to Parliament set out that their purpose was to construct and operate irrigation ditches in that portion of the District of Alberta lying south of the 50th parallel of latitude. Political and financial difficulties hindered them so that they did not succeed in starting construction work until 1898. Further reference to this company will be made later.

#### Calgary Irrigation Company

The Calgary Irrigation Company proceeded promptly with their plans. They located their headgate on the Elbow river, in section 4, township 24, range 4, west of the 5th meridian, 18 miles west of Calgary. By the end of the year 1893 they had completed their headworks and six miles of main ditch. This company was the pioneer irrigation company in the Prairie Provinces, and constructed altogether 81 miles of main and distributing ditches to serve 45,000 acres of land south of the Elbow and Bow rivers in the neighbourhood of Calgary. The first irrigation water was applied in the summer of 1894, but unfortunately the completion of their works was followed by a cycle of

Fig. 2—Main Canal Looking North towards Oliver.

Fig. 3—Metal Flume, South Okanagan Project, B.C.

wet seasons, during which irrigation was not required, the works were very little used, and were finally abandoned.

### Calgary Hydraulic Company

The Calgary Hydraulic Company, also chartered in 1893, proceeded vigorously with their plans, and by August of that year had commenced construction. Their headgate was located on the south bank of the Bow river in the southwest quarter of section 4, township 25, range 2, west of the 5th meridian, seven miles west of the city of Calgary. At a point about three miles below the headgate the ditch crossed to the north side of the river by means of 1,500 feet of 30-in. wooden pipe supported at the river crossing by a truss bridge of two spans. This is reported to be the first structure of its kind to be erected in the Northwest Territories and attracted considerable interest. (See Fig. 4.)

Fig. 4—Bridge and Barrel Flume across Bow River. Constructed 1894.

The works were completed in September 1894 and water was supplied in the fall of that year for fall irrigation. The main canal had a capacity of 25 c.f.s. and was built to serve 2,500 acres, a portion of which was within the limits of the city of Calgary.

The bridge carrying the pipe line, or barrel flume as it was termed, across the Bow river, was destroyed by flood in June 1897 and was not rebuilt. Thus the irrigation system was abandoned after two years of operation, but the upper end of the canal is still used to supply water to the lagoons and pools used extensively for canoeing, wading and swimming in Bowness Park, owned and operated as a recreation park by the city of Calgary.

### Springbank Irrigation District

About this same time an agitation was initiated by the farmers west of Calgary who wished to irrigate their lands lying between the Elbow and Bow rivers in what was known as the Springbank district. This agitation led to the enactment of the Northwest Irrigation District Ordinance in 1894, which provided for the erection of an irrigation district with powers to levy assessments against lands within the district for the purpose of the construction and operation of irrigation works. It was the first act of its kind in Canada and was patterned after the Wright Act in California, prescribing a method of operation similar to that in the case of a school district or municipality. An interesting feature of this act was that it placed a limit of $6 per acre for cost of construction and $1 per acre per year for operation, maintenance and sinking fund. It was argued that any cost in excess of these figures was prohibitive.

Pending the formal erection of the district a memorial was filed in the Land Titles Office at Calgary on November 5th, 1894, for permission to divert water from Elbow river on the southwest quarter of section 4, township 24, range 4, west of the 5th meridian to irrigate 21,200 acres. A second memorial was filed February 13th, 1895, to divert water from Jumping Pound creek on the southeast quarter of section 13, township 24, range 5, west of the 5th meridian, to irrigate 30,778 acres. An Order-in-Council was passed February 25th, 1896, authorizing the construction of the proposed works. The project was never completed, but its history is recorded here for the reason that it was the first canal projected in Canada as a mutual undertaking under the provisions of an Irrigation District Act, and consequently was looked upon as an event of more than ordinary interest.

### Alberta Irrigation Company

The only one of the early projects of any size which continued in operation was the one under the charter of the Alberta Irrigation Company.

As already noted, the Mormons had settled around Cardston. Being accustomed to irrigation they saw great possibilities in the vast fertile plains to the east and north of their settlement if the deficient rainfall could be supplemented by irrigation. With a view of colonizing and irrigating these lands Charles Ora Card undertook to purchase 116,000 acres and John W. Taylor 595,000 acres on the terms of a rental payment of two cents per acre per year for four years from 1892 to 1895, and then a purchase price of $1 per acre, spread over eight years, with interest at six per cent.

These contracts were made in December, 1891. In December of the following year notice was given that application would be made to Parliament at its next session for "an Act to incorporate a company for the purpose of constructing and operating irrigation ditches or canals in that portion of the district of Alberta lying south of the fiftieth parallel of latitude where it passes through the said district." The original purpose of this application was to obtain an act which would assist Mr. Taylor and his associates in their colonization and irrigation enterprise. Sir Alexander and Elliott T. Galt allowed their names to be used in the application to assist in getting the act through Parliament, but they did not intend to take an active part in the affairs of the new company. However, when the act was assented to in April 1893, and the Alberta Irrigation Company was formed, Sir Alexander Galt was made President. Upon his death in September of the same year, he was succeeded as President of the Alberta Railway and Coal Company (and presumably of the Alberta Irrigation Company) by Mr. Peter Redpath, who died three months later, when Elliott T. Galt became President.

By this time the agitation for irrigation in this district was so well advanced that in the Lethbridge Board of Trade in 1893, it was moved by C. A. Magrath, seconded by W. A. Galliher, that "the promotion of irrigation in this district of Southern Alberta is absolutely necessary for the development of the district, and it is deemed advisable to place the matter properly before the Government and that a Joint Commission, composed of men from Lethbridge, Macleod and Calgary, be appointed to collect evidence, statistics, etc., and that we set aside $200 to cover our share of the necessary expenses."

*Surveys Undertaken*

As already stated an irrigation act had been passed in 1894. At the same time the Government adopted the policy in connection with irrigation development that it would determine what was feasible in the way of irrigation and then leave it to private enterprise to do the rest. In line with this policy, Mr. J. S. Dennis undertook topographical surveys and stream flow measurements to determine what water supply was available and what land could be irrigated. But it did not prove to be an easy matter to interest sufficient capital and enough people to construct a big irrigation system and colonize the lands. So John W. Taylor failed in his ambitious enterprise and his contracts for the purchase of the land were cancelled in 1895.

One of the difficulties encountered by Taylor and by the company was that the lands were located in blocks of alternate townships which made irrigation development in a practical way impossible. Repeated representations to the Government and frequent visits to Ottawa by Mr. Galt and Mr. Magrath were made in this connection, but it was not until 1896, when a western man, the Honourable Clifford Sifton, who was familiar with the conditions, was appointed Minister of the Interior, that the company's land grant was consolidated into a solid block and the irrigation scheme became feasible.

In the meantime the Alberta Irrigation Company had not exercised the functions for which it was organized and as the time for beginning construction had been limited to three years from the date of the incorporation and was now about to expire, a new act was passed in April 1896 to revive and amend the previous act. In the following year Mr. George G. Anderson, an eminent irrigation engineer of Denver, Colorado, was engaged to report on the feasibility and cost of an irrigation system to serve the company's lands. So in 1896 the actual location of the canal was started by the Alberta Irrigation Company. E. T. Galt was then president, C. A. Magrath, manager, G. G. Anderson, consulting engineer, C. F. P. Conybeare, solicitor, and Hugh MacBeth, accountant.

*Work begun on the Big Ditch*

Mr. Anderson started work with his parties in July 1898, A. M. Grace being chief assistant engineer; and by December they had about forty-five teams at work on the first division.

The chief contractors for the ditch were the President and High Council of Latter Day Saints—The Mormon Church—and the sub-contractors, labourers and teamsters were principally Mormon farmers who came to settle in Canada. These men were paid one-half in cash and one-half land; the land with water right being valued then at $3.00 per acre, and located at Magrath and Stirling. These towns were then just being started by the men working on the ditch. Cardston was an older settlement.

| Constructed systems | Irr. acres | Proposed or projected | Irr. acres |
|---|---|---|---|
| 1. C.P.R. Western Section... | 218,980 | 14. Lethbridge South Eastn.. | 350,000* |
| 2. Eastern Irrigation Dist.... | 400,000 | 15. South Macleod Irr. Dist.. | 50,000* |
| 3. Canada Land & Irr. Coy.. | 210,000 | 16. Eyremore Irr. Dist....... | 4,100 |
| 4. Alta. Rly. & Irr. Co....... | | 17. Retlaw-Lomond Dist..... | 70,000 |
| (C.P.R.)............... | 87,000 | 18. River Bow Irr. Dist...... | 5,800 |
| 5. Taber Irrigation Dist...... | 21,661 | 19. Medicine Hat South Dist. | 7,000* |
| 6. Magrath Irrigation Dist... | 5,000 | 20. Medicine Hat East Dist.. | 4,000* |
| 7. Raymond Irrigation Dist.. | 6,400 | 21. Champion Irr. Dist...... | 50,000 |
| 8. Lethbridge Nt. Irr. Dist... | 93,000 | 22. Little Bow Irr. Dist...... | 3,000 |
| 9. United Irrigation Dist..... | 36,000 | 23. North. Sask. Project ..... | 1,400,000* |
| 10. New West Irr. Dist....... | 4,500 | | |
| 11. Mountain View Irr. Dist.. | 2,500 | Small private schemes, Alta.. | 56,000* |
| 12. East End Irr. Dist........ | 2,500 | Small private schemes, Sask.. | 50,000* |
| 13. Val Marie Irr. Dist....... | 6,000 | | |

*Approx.

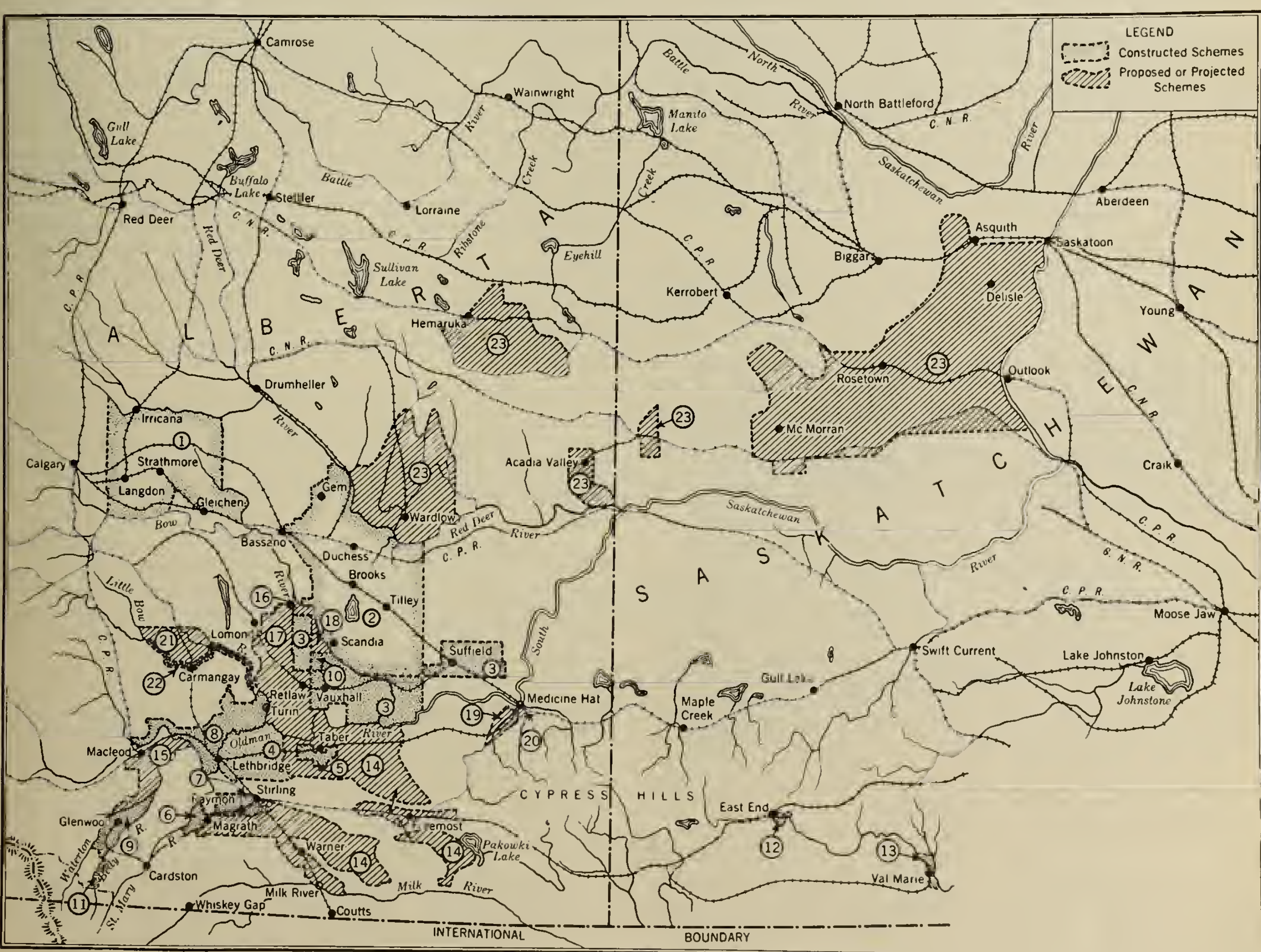


Fig. 5—Map showing Irrigation Projects in Alberta and Saskatchewan.

The whole work was done with teams, and all supplies and lumber for the structures had to be teamed from Whoop-up, a siding on the old Crow's Nest line about five miles south of Lethbridge. The intake on the St. Mary river at Kimball was about 40 miles south and 18 miles west of that point. Over a million feet of lumber was required, most of it being used in the headworks and flumes near the upper end of the system. In wet seasons the work of teaming presented serious difficulties, as some of the creeks and coulees were at times like rivers, and there were no bridges. Indians and anyone else with teams could get work. It is said that lumber was scattered over the prairie all the way from Whoop-up to Kimball where the Indians had got stuck and thrown off and abandoned part of their load. Neither steam shovels or dredges were employed in the excavation, which amounted to 1,121,000 cu. yds.

In 1899 by Act of Parliament the name of the company was changed from the Alberta Irrigation Company to the Canadian Northwest Irrigation Company. In the meantime construction was progressing rapidly.

*Contract with the City of Lethbridge*

As projected the canal was to irrigate land adjacent to Magrath and the valley running between Milk River ridge and the Rolling Hills, with Stirling as the terminal point. When the people of Lethbridge found that the company did not intend to build the canal to Lethbridge, they were much exercised. So the town, under Dr. Mewburn as mayor, induced the company under certain conditions as set forth in By-law No. 107, to build into Lethbridge. This by-law provided that "in consideration of $20,000 paid by the town to the company, they would build the canal to the town limits and deliver for the use of the inhabitants for fire, domestic and cultivation purposes, five cubic feet a second during the irrigation season, for twenty-five years, free of rental, and spend $4,000 in making ditches in town." The ratepayers voted on this by-law on June 29th, 1899, the vote being 85 for and 1 against. The company therefore changed its plans accordingly and brought its main canal into the Lethbridge district.

*First irrigation water reaches Lethbridge*

Water was turned in at the head of the canal on July 4th, 1900. It reached the limits of the town of Lethbridge at three o'clock in the afternoon of September 4th, 1900, and to the particular delight of the small boys, as well as the citizens in general, it flowed through the ditches along the streets of the town. The laterals into Magrath and Stirling were not completed until the following year, water reaching the town of Stirling July 12th, and Magrath July 25th, 1901. The canal was formally opened by His Excellency the Earl of Minto, Governor General, on September 14th, 1900.

### The Alberta Railway and Irrigation Company

In September 1904 the Alberta Railway and Irrigation Company was formed, being successor to the Alberta Railway and Coal Company, the Canada Northwest Irrigation Company and the St. Mary River Railway Company. In 1912 the Canadian Pacific Railway Company took over all the interests of the A. R. and I. Co., and has since that date operated the irrigation works which are, however, still known as the A. R. and I.

As first constructed, the A. R. and I. canal had a capacity of 400 c.f.s. It has been enlarged and extended from time to time until it now has a capacity of 1,200 c.f.s. As already stated, the original construction required a million feet of lumber and the excavation of 1,121,000 cu. yds. of earthwork. Later enlargements and extensions called for 3,250,000 ft. of lumber and 3,800,000 cubic yards of earth, or a total for the system as it now is of four and a half million feet of lumber and nearly five million cubic yards of earthwork.

Including the Magrath, Raymond and Taber Irrigation Districts, which are supplied by it, the A. R. and I. system serves an irrigable area of approximately 120,000 acres east and south of the city of Lethbridge.

### The Canadian Pacific Railway Irrigation Project

The most extensive irrigation enterprise in Canada is the system constructed by the C.P.R. to serve a large tract of land along its main line between Calgary and Medicine Hat.

When the Canadian Pacific Railway was constructed, a part of the consideration was a land grant of some 22,000,000 acres in the provinces now known as Manitoba, Saskatchewan and Alberta. The land was to be given in alternate sections, 20 miles each side of the main line, and the Company had the privilege of rejecting any land which was not reasonably fit for agriculture, making up the deficiency elsewhere. Under this clause the company declined to accept land between Moose Jaw and Calgary, and when the time came for final settlement there was still a large area wanting to complete the grant. The company then agreed to take some 3,000,000 acres in a solid block between Calgary and Medicine Hat, and construct an irrigation system to serve it.

The feasibility of diverting water from the Bow river near Bassano had been investigated by William Pearce as early as 1893 and a comprehensive report on the irrigation block as a whole was made in 1901 by George Anderson, consulting engineer, of Denver. His plan was that the whole block should be served from one intake on the Bow river near Calgary. The final result of further surveys and investigations was that the intake near Calgary should serve the western and central sections, and that Bassano was chosen as the point of diversion for the eastern section.

When the C.P.R. decided to undertake this large project it engaged J. S. Dennis to make further detail surveys and carry out the construction of the project. William Pearce also joined the C.P.R. service about the same time. The responsibility for carrying out this great undertaking may be largely credited to their efforts. Other engineers who figured prominently in the construction days were A. S. Dawson, M.E.I.C., chief engineer, and H. B. Muckleston, M.E.I.C., assistant chief engineer, under whose direction preliminary and final surveys were made and construction carried out.

The Irrigation Block is divided into three sections, namely—

The Western Section, comprising a total of 1,022,300 acres, of which 218,980 acres were classified by the government as irrigable. This project lies immediately to the east of Calgary with operating headquarters at Strathmore, supplied by direct diversion from the Bow river near Calgary.

The Eastern Section, comprising a total of 1,245,730 acres, of which some 400,000 acres were classified by the government as irrigable. This project lies to the east of Bassano, with operating headquarters at Brooks, and is supplied by direct diversion from the Bow River near Bassano.

The Central Section lies between the Western and Eastern Sections and some 240,000 acres were classified as irrigable. Upon further study it was found that on the whole the natural features, topography and cost were not favourable, and so no development was undertaken in this section.

*The Western Section*

This project was started first on account of its proximity to Calgary; construction was commenced in 1903 and completed in 1910. The altitude of the Western Section varies from about 3,315 ft. above sea level, where the irrigable lands begin on the western side, to 2,650 ft.

Fig. 6—Diversion Weir and Main Canal Headgates, Bow River, Calgary.

at the eastern limit. The gate sill of the intake on the Bow river at Calgary is at elevation 3,354.

The canal system as constructed consists of the main canal, with a maximum capacity of 2,100 sec. ft., running from Calgary headworks for 16 miles to Chestermere lake—a balancing pool, about 3 miles long and 1½ miles wide—three secondary canals taking out of Chestermere lake, branch canals from the secondary canals, and a network of distributary ditches and spillways. The total length of all constructed canals, distributary ditches and spillways is approximately 1,733 miles.

The original intake on the Bow river near Calgary was a timber structure diverting directly from the river through 20 gates, 3 ft. wide and 10 ft. high. This structure was replaced by reinforced concrete headgates and a diversion weir of three parts, completed in 1914. The present headgate structure has four openings, each 18½ ft. clear width, with Stoney sluice gates operated either by hand or electrically.

The diversion weir, extending across the river from the headgates, consists of a movable sector weir 152 feet long, a stoplog section 550 ft. long and an earth embankment containing a breaching section 200 ft. long. (See Fig. 6.) The sector is a steel trussed frame covered with skin plate on the two exposed sides. It is hinged to the floor and operated by hydraulic pressure from the water admitted to the concrete chamber in which it moves. (See. Fig. 7.) The stop-log section is built of reinforced concrete and contains twenty-three openings, each 20 ft. wide. The stop-logs are handled by an electrically operated traveller on the concrete deck of the weir.

The control structures on Chestermere lake are of timber construction, but most of the structures on the principal canals are built of reinforced concrete, many of them replacing old timber structures.

A number of the reinforced concrete drops on the larger canals are of the Indian notch type, from which in subsequent years the intermediate piers have been removed, so as to avoid weed jams which have frequently occurred and caused trouble in operation.

Most of the smaller structures in the distribution ditches were constructed of timber, but since the project has been in operation nearly all of them have been replaced at least once and many additional structures have been built in an adjustment of grades and in taking up the fall in natural channels. Replacements were mostly of timber, a large quantity of which included lumber pressure-treated with creosote oil.

In the original construction of the Western Section, a total of over 10,000,000 cu. yds. of earth was excavated and the timber in structures required about 9,000,000 ft. for division gates, drops, flumes, bridges, culverts, turnouts, etc. Capital expenditures for construction and subsequent improvements have amounted to nearly six million dollars.

The climate is favourable for grain growing and stock raising. Grain being the principal crop, and most of the farms being in large units, comparatively few of the farmers make a serious attempt to practise irrigation. Many of them have petitioned to have their water rights cancelled and as a consequence the total area served has been considerably reduced.

*The Eastern Section*

The Eastern Section (now the Eastern Irrigation District) lies between the Bow river and the Red Deer river and extends eastward from Bassano to the line between ranges 10 and 11, west of the 4th meridian, a distance of 48 miles. The topography is favourable to irrigation development, the surface slopes being moderate, making the delivery of water comparatively easy. The altitude varies from about elevation 2,550 at the western edge to 2,350 at the eastern limit.

The average precipitation recorded at Brooks is approximately 12 in. per annum. Extreme temperatures vary from a maximum of nearly 100 deg. F. in the summer to −40 deg. F. in the winter, but rarely occur, the average mean annual temperature being about 40 deg. F. Hours of sunshine and evaporation are high. The frost-free period averages about one hundred and twenty-one days in the year. Snowfall is not heavy and most of the roads are passable in the winter.

Authorization for construction of the project is dated April 21st, 1904. Construction was commenced in 1910, beginning with the Bassano dam and the project as a whole was completed in 1914.

The duty of water and the duration of the irrigating season is the same as for the Western Section, namely 2 acre feet per acre applying to irrigable contracts entered into prior to March 25th, 1919, and 1.5 acre feet per acre applying to contracts made subsequently. The irrigating season is from May 1st to October 1st.

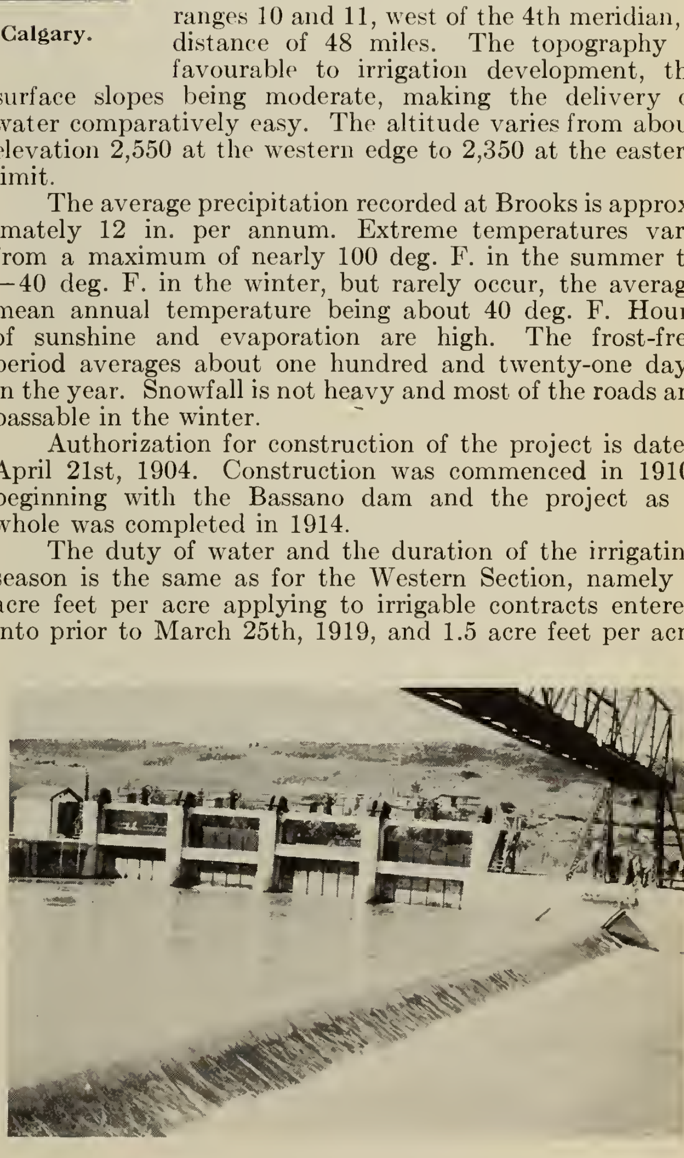

Fig. 7—Headgates of Main Canal and Movable Sector Weir, Bow River Canal.

The main canal, with a maximum capacity of 3,800 sec. ft., runs easterly from Bassano dam about 4½ miles to Little dam where a balancing pool is created at the head of the two principal canals—the East Branch and the North Branch canals. The total length of constructed main, secondary and smaller laterals in the system is approximately 2,250 miles.

Lake Newell reservoir is filled through the East Branch canal. It is approximately nine miles long and four miles wide. At full supply it has a storage capacity of 259,600 acre feet over the sill of Bantry canal headgates and a surface area of 16,666 acres. Its maximum depth is about 52 ft. The structures on the East Branch canal were designed for winter operation.

All the important structures and many of the lesser ones were built of concrete, there being a total of approximately 100,000 cu. yds. placed in structures, including Bassano dam and Brooks aqueduct. The total amount of lumber used in the construction of timber structures was about 9½ million feet. The three most important structures on the project are Bassano dam, Brooks aqueduct and Antelope creek siphon.

Bassano dam, which at one time was rated as one of the most important structures of its kind in the world on account of its composite character, great length, peculiar foundations and the depth of water which flows over its crest in flood periods, consists of a long, high earthen embankment on the south bank of the river and a reinforced concrete spillway in the existing river channel, connected at its northerly end with the headgate structure for the main canal. (See Fig. 9.)

The embankment is 7,200 ft. long with a maximum height of 45 ft. and contains approximately 1,250,000 cu. yds. of material, which was mostly transported from the main canal cut on the opposite side of the river.

The spillway portion of the dam is of the so-called Ambursen hollow type. It is 720 ft. long, with a maximum height of 65 ft. to the lowest foundation and 40 ft. from the bed of the river to the crest, the controlled water depth on the crest being 11 ft. There are twenty-four openings in the spillway, each 27 ft. clear width, with electrically operated structural steel sluice gates of the Stoney type at crest level. Electric power for operating the gates and for illumination is generated in the dam. A roadway ten feet wide extends across the top of the structure. This type of dam is hollow and derives most of its stability from the weight of the water on its back. The foundations are in a thick blanket of clay overlying a more porous sub-stratum.

Fig. 8—Winona Semi-circular Metal Flume, 7 ft. 2 in. diameter, Arch Span 64 ft.

The main canal headgate structure, an integral part of the dam, has five openings, each 20 ft. clear width, with steel gates of the Stoney type, which can be operated either by hand or by electricity. The concrete portion of the dam contains approximately 55,000 cu. yds. of concrete, 3,000,000 lb. of reinforcing steel and 500 tons of structural steel. The total cost of the complete structure was about $1,500,000.

Brooks aqueduct, on the main Bantry canal, carries the water for the Bantry system across a valley about four miles down stream from Lake Newell reservoir. The problem of crossing this valley was one of the most difficult engineering problems encountered in the whole system. The valley is two miles wide and 60 ft. deep and the main line of the C.P.R. runs through it.

The aqueduct is a reinforced concrete grade flume on a concrete trestle, having its section shaped to the hydrostatic catenary—the shape the water would assume in a flume running full, if a flexible material were used for the barrel. A rigid shell of reinforced concrete five inches thick was constructed to this shape, having an interior width at full supply level of 21 ft. 4½ in. and a maximum depth of 8 ft. 8¼ in. The advantage of this particular section in concrete construction is that under full load, moment and shear in the shell are zero. (See Fig. 10.)

The water is passed under the railway through an inverted siphon designed on the Venturi principle, the section of the barrel immediately under the track being 9 ft. 9 in. in diameter.

The total loss of head in the complete length of the aqueduct, including the siphon and reducing channel at inlet, is 4.85 ft. The maximum rated capacity is 700 c.f.s. The aqueduct contains 25,000 cu. yds. of concrete and 4,000,000 lb. of steel. The total cost was approximately $700,000.

Antelope Creek siphon is located on the East Branch canal about 30 miles below Bassano dam where it crosses one of the main divides of the country. Its maximum capacity is 1,200 sec. ft. The original structure consisted of five reinforced concrete pipes, 5 ft. in diameter, 1,740 ft. long, with inlet control, built in 1914. In 1917 it was found necessary to replace 850 ft. of two of the pipes with wood stave pipes in the lowest part of the valley, where rapid deterioration had taken place from alkali in the soil in which they were buried. In 1921 the three remaining pipes were replaced with one large wood stave pipe 90 in. in diameter on pile foundations.

In addition to the above, there are many important structures which vary considerably in design to suit the conditions for which they are required. Some of the more recently constructed gates are of the radial type, and a few have automatic control.

There are a number of large timber flumes on pile foundations over depressions and natural water courses, the two most important being the Lathom and Crawling valley grade flumes of wood stave construction, both 15 ft. diameter at full supply level, with capacities of 978 and 673 c.f.s., and lengths of 2,593 and 1,388 lineal feet respectively. (See Figs. 11 and 12.) All the timber was pre-cut and the staves milled to radius and cut to length

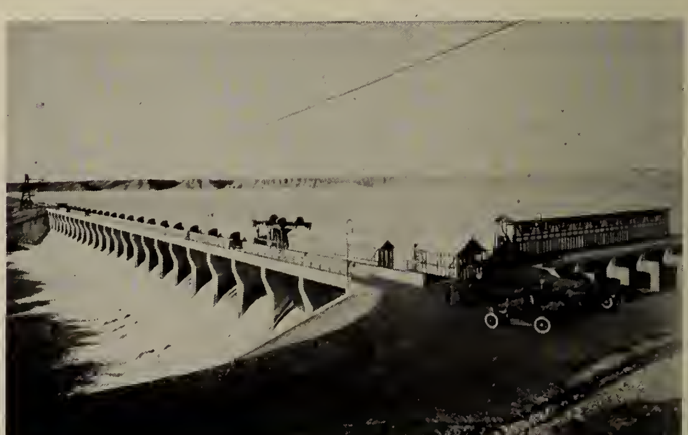

Fig. 9—Bassano Dam and Main Canal Headgates, Bow River.

Fig. 10—Brooks Aqueduct during Construction.

before pressure treatment. This is a very satisfactory type of construction. Gravity tends to keep the staves in close contact and the flume watertight, even when the staves shrink from long periods of dryness and the flume bands get loose.

Also the simplified design of the structure is interesting and is both effective and economical. The pile supports are cut off at subgrade and the tops treated with hot creosote and pitch and then covered with a metal plate before being capped. This is the only field cut in erection, aside from a few bolt holes to be bored. There are no framed bents so the number of end joints is reduced to a minimum. Cradles are not attached to pile caps so that adjustment can be made by wedging if ever necessary. Cradles are held in place by cleats nailed to pile caps, both sides and end. Overturning of flume by wind is prevented by long rods from top of flume to pile caps.

For general irrigation construction, particularly in alkali soils, treated timber has been found very satisfactory. It is readily adaptable to varying requirements of construction and repairs, and has long life.

Capital expenditure for original construction and subsequent improvements had amounted to more than $12,000,000 when the Eastern Irrigation District took over the project on May 1st, 1935.

### The Canada Land and Irrigation Company

The project of the Canada Land and Irrigation Company was formed by the amalgamation of three predecessor companies, namely, the Southern Alberta Land Company, the Alberta Land Company and Canadian Wheat Lands. The two first named companies had obtained from the Dominion Government an agreement to purchase approximately 450,000 acres of land for $1.00 per acre on condition that the companies would construct irrigation works, satisfactory to the Government, to irrigate one quarter of the irrigable area. An additional area of approximately 80,000 acres of land was purchased, consisting largely of school, Hudson's Bay and privately owned lands, thus bringing the total area in the project, including canal right of way, to over 532,000 acres. Out of this area it was found that about 210,000 acres could be irrigated. As the lands were largely contiguous and could be irrigated by only one canal system and point of diversion for water supply from the Bow river, the Southern Alberta Land Company, subject to agreements with the other companies for reimbursement for costs, undertook the construction of works to serve all of the irrigable lands. Work of surveys and construction started about 1909 and progressed rapidly until the advent of war in 1914. Work was stopped in September 1914. In 1917 the three companies were amalgamated, forming the Canada Land and Irrigation Company. Work was resumed by this company in the latter part of that year and the settlement of irrigable land started in 1919.

*Description of works*

By this time the construction of the main canal had been extended for a distance of over 200 miles through the country, in addition to which there were many miles of branch canals, laterals and appurtenant structures. The main feature of the work consists of two dams across two channels of the Bow river, each about 10 feet high and 550 feet in length. From the point of diversion from the river a supply canal, 44 miles in length, was built to a reservoir, Lake McGregor. This reservoir was formed by two concrete paved earth dams respectively 44 ft. and 41 ft. in height and 3,580 and 1,993 ft. in length. The dams form a reservoir about 25 miles in length and one-half to three miles in width and at maximum capacity would store 300,000 acre feet of water. From the outlet structure of this reservoir a canal 14 miles long extends to a second

Fig. 11—Lathom, Semi-circular Wood Stave Flume 15 ft. diameter, 2,593 ft. long.

reservoir, Little Bow reservoir. This section of canal, approximately eight miles, is along the steep side hill slopes adjacent to the Little Bow river and involved a difficult and hazardous location for canal construction. Deep cuts and high embankments of 50 ft. for long stretches are a frequent occurrence in this eight miles. The canal at the lower end of the 14 miles emerges from the Little Bow canyon and enters the Little Bow reservoir. This reservoir was made in a saucer-like basin by excavating a channel to the bottom of the basin and by the construction of an earth dam 24 ft. maximum height and 3,963 ft. in length across a low part of the rim of the basin. It has a capacity of 30,000 acre feet and serves largely as a regulator in the supply of water for irrigation. From the Little Bow reservoir the canal extends approximately 27 miles to the first irrigable lands of the project, making a total of 110 miles from the point of diversion of water to the first point of use. Thence the main canal was extended an additional 100 miles through lands of the holding companies. A fall of approximately 600 ft. occurs in the total length of canal, of which about 200 ft. is taken up by 14 drops and the remaining fall is in canal gradient. From this main canal 78 miles of branch canals were built and approximately 200 miles of lateral ditches have been built to date. Over 100 main canal structures, flumes, siphons, bridges, drops, etc., and nearly 1,400 lateral structures of concrete and wood are in the irrigation system.

The cost of these works probably exceeded $7,000,000 and all costs including land investments, interest on debentures, colonization and other costs to date approximate $17,000,000. At this time 40,000 acres of land are irrigated out of the 210,000 for which the project was originally planned. It would take $3,000,000 to complete the scheme to the ultimate possibilities of the project.

### Irrigation Districts

In 1915 the Alberta Legislature enacted the Irrigation

Districts Act. All new irrigation enterprises in Alberta since that date have been carried out under its provisions.

### Taber Irrigation District

The Taber Irrigation District was the first one to be established under the Irrigation Districts Act of Alberta. The farmers in the district began negotiations with the C.P.R. about 1913 for a water supply for their lands. The company had constructed reservoirs in Chin Coulee for the storage of the waste and surplus water from their Lethbridge system, and surveys had shown that this water could be economically applied to the lands around Barnwell and Taber. The original proposal was that the company should build the irrigation works and accept contracts from the individual land owners, the contracts to be secured by mortgages on the farm lands. But this proved to be impracticable, so the Alberta government was asked to pass legislation which would enable the farmers to organize a district and issue bonds to cover the cost of irrigation works. The Irrigation Districts Act was passed by the Alberta Legislature in 1915 and in the same year the Taber Irrigation District was erected. After a number of delays, negotiations with the C.P.R. were completed in the spring of 1919, and in July of that year the land owners voted unanimously for the issue of bonds for the construction of their canals. The C.P.R. accepted the bonds for the actual cost of the construction of the works, which amounted to $16.50 per irrigable acre. Construction was started July 24th, 1919, and completed in October 1920. The first water was turned into the canal September 10th, 1920, and the canals were primed and about 2,000 acres of land were fall irrigated that season. The original contract called for the delivery of 34,000 acre feet per annum at the headgate of the Taber canal for the irrigation of 17,000 acres. The area entitled to irrigation was afterwards increased to 21,661 acres. The system is operated by the farmers themselves, and has been successful from the start.

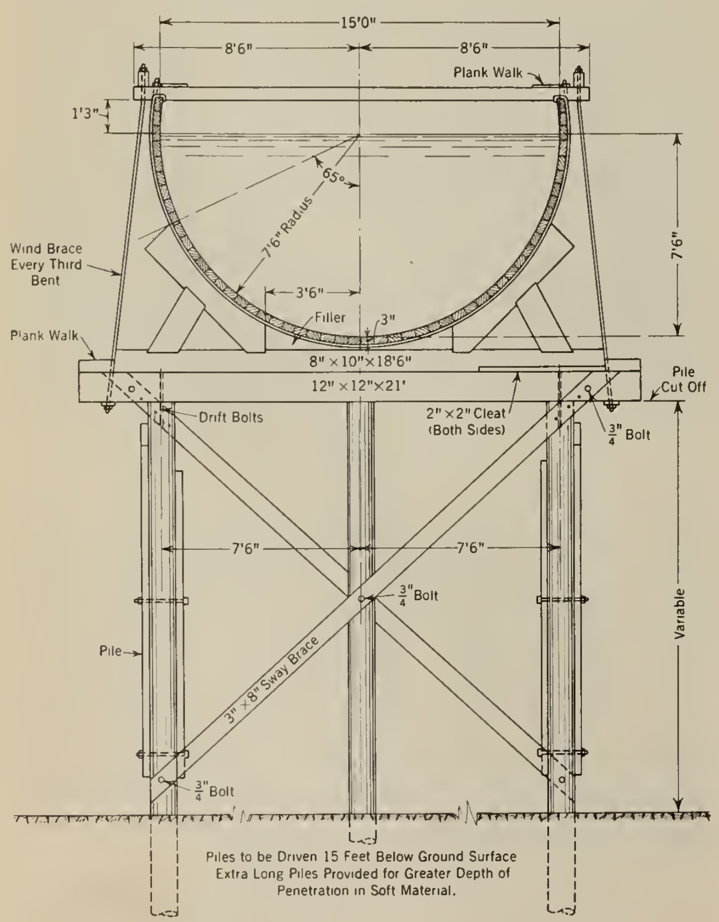


**Fig. 12—Section of Lathom Flume.**

### Lethbridge Northern Irrigation District

As early as 1910 a petition was forwarded to the Government by settlers in the Iron Springs District for the construction of an irrigation system to supply water to their land. Their proposal was to pump water from the Oldman river immediately south of Iron Springs, but as this involved a lift of 300 feet, little study was required to show that it could not be done within the limits of reasonable cost.

Several other possibilities were inquired into but the first actual surveys were made by the Dominion Government in 1913 when the plan of taking water from the Oldman river on the Peigan Indian Reserve, about 10 miles west of Macleod, was recommended as the most feasible scheme. The surveys were continued each season to define in greater detail all the elements of location, cost and areas which could be irrigated.

The Lethbridge Northern Irrigation District was erected by vote of the land owners on September 20th, 1919, the vote being 288 in favour to 8 opposed. It covers an irregular tract of land lying on the north side of the Oldman river extending from Macleod on the west to Turin on the east. The district contains about 230,000 acres of which 105,000 were classified as irrigable. Reclassification has reduced the irrigable area to about 93,000 acres.

The bonds could not be disposed of on acceptable terms until they were guaranteed by the provincial government. This was done in the spring of 1921 and a contract was let on June 1st, 1921, covering the excavation of 7,300,000 cubic yards of material. The earthwork contract was completed October 19th, 1922, and the structures by May 1923. The cost of construction, apart from interest and carrying charges, was $4,171,580.35. The total bond issue which covered construction costs, engineering, interest, administration and other costs during construction, and discount on sale of bonds was $5,400,000, in thirty-year 6 per cent bonds guaranteed as to interest and principal by the provincial government.

Water was turned into the canal May 1st, 1923, but on the last day of May and the first few days of June an unprecedented flood in the Oldman river washed out two or three miles of the main canal and two sections of the flume over the Oldman river. These damages cost the district nearly $100,000 and required all summer to repair, so that no more water was run until October. In 1924 the system was operated for the full season and nearly 30 per cent of the total irrigable area was irrigated.

The diversion dam on the Oldman river is a concrete structure 524 ft. long and 6½ ft. high. (See Fig. 13.) The headgate structure is also of concrete, the gates being of the Stoney type. The main canal is 33 ft. wide on the bottom and designed to carry 800 c.f.s. at a depth of 7 ft. Four miles from the intake the canal passes from the south to the north side of the river through a semicircular galvanized sheet iron flume 14 ft. wide at the top and 3,322 ft. in length. Approaching the river it is supported on wooden trestles resting on concrete pedestals, and it crosses the river by a steel bridge (see Fig. 14). Other important structures on the main canal are the Willow creek flume similar to the one just described, and the Rocky Coulee and White lake inverted siphons, each being of wood stave pipe construction 10½ ft. in diameter and 2,855 ft. and 930 ft., respectively, in length. Hundreds of other structures of various types carefully designed to meet their particular requirements are found on the main and distribution canals. The larger and more important ones as a rule are of concrete construction, the smaller ones of timber. (See Fig. 15.)

The main canal empties into Keho lake, southeast of Barons, which provides storage capacity for about 40,000 acre feet for the eastern end of the district.

H. B. Muckleston, M.E.I.C., was chief engineer during

**Fig. 13—Diversion Dam, Sluice Gates and Headgates on Oldman River.**

**Fig. 14—Metal Flume on Timber Trestle at Oldman River Crossing.**

construction. P. M. Sauder, M.E.I.C., has been project manager in charge of operation.

### The United Irrigation District

A large tract of land known as the Cochrane Ranch, lying between the Belly and Waterton rivers in southwestern Alberta, was purchased and colonized by the Alberta Stake of Zion (The Mormon Church in Alberta) and as early as 1906 the Stake made application to the Dominion Government to irrigate it, and went to considerable expense making surveys for the irrigation of some 45,000 acres. Authorization was granted in 1907 for the diversion of water from the Waterton river for this purpose but the surveys showed that the cost would be excessive so no construction was undertaken and the authorization was cancelled in 1910.

Afterwards another survey indicated that it was feasible to divert water from the Belly river to serve a large portion of this land, and in the dry season of 1918 the farmers in the neighbourhood of Hill Spring and Glenwood, having lost their crops through drought, determined to build the ditch themselves and actually started work on it. But proper surveys had not been made and the authority of the Government had not been obtained, so that little was accomplished.

In March 1919, the Alberta Stake of Zion made a new application for water, this time from the Belly river instead of the Waterton, and the Dominion Government undertook to make a complete survey of the scheme.

In August 1919, the United Irrigation District was erected. In March 1920, another district comprising lands adjoining the United District on the north and east was erected under the name of the Lone Rock Irrigation District. Since these two districts would be served by the same system of canals, the majority of the land owners in the Lone Rock district petitioned the Minister of Public Works of Alberta to be included in the United District. Consequently, by order of the Minister, signed March 2nd, 1921, the Lone Rock Irrigation District was dissolved and the lands which it comprised were added to the United Irrigation District.

Construction work was commenced in October 1921 and completed in the fall of 1923. A feature of the construction of this system was that the contracts were let to the ratepayers in preference to regular contractors. The system covers some 36,000 acres of irrigable land, and cost about \$15 per acre which was covered by the issue of \$550,000 in thirty-year 5½ per cent bonds guaranteed by the provincial government.

### Other Irrigation Districts

Other irrigation districts smaller than the ones above described, have been organized in Alberta, as follows:

The New West Irrigation District was erected in 1923 to irrigate about 4,500 acres north of Retlaw. It gets its water supply from the Bow river through the main canal of the Canada Land and Irrigation Company.

The Little Bow Irrigation District, erected in 1923, diverts water from the Highwood river to the Little Bow river at High river. It was contemplated that individual water users would pump this water from the Little Bow river for the irrigation of about 2,800 acres, but no pumping plants have yet been installed. The diversion serves however to keep up the flow of the Little Bow river for livestock and domestic supplies.

The Mountain View Irrigation District was erected in 1923 for the irrigation of about 2,500 acres east of the Belly river in township 2, range 28, west of the 4th meridian. Construction work was allotted to each of the various interested parties to carry out themselves without the issue of debentures. It has proceeded spasmodically ever since, some progress being made in dry years and practically none in wet years.

The Magrath Irrigation District was organized in 1924 to irrigate about 5,000 acres near the town of Magrath. It gets its water supply from the Alberta Railway and Irrigation system. The C.P.R. constructed the works, accepting the debentures of the District in payment.

The Raymond Irrigation District was erected in 1925 to irrigate about 6,400 acres near Raymond in addition to that already irrigated under the A. R. and I. system. This district also receives its water supply from the A. R. and I. canal.

### Eastern Irrigation District

In 1934 the farmers in the Eastern Section of the C P.R. Irrigation Block approached the company with a proposal for the organization of an Irrigation District and the transfer of the irrigation system to the District. These negotiations resulted in the erection of the Eastern Irrigation District and the transfer of the entire holdings of the C.P.R. within the boundaries of the District, including a million and a quarter acres of lands as well as the entire irrigation system to the Board of Trustees of the District. The agreement was ratified by a special Act of the Provincial Legislature and became effective May 1st, 1935. The system has already been described under the title of the C.P.R. Eastern Section.

### Irrigation in Saskatchewan

Irrigation development has not been so extensive in Saskatchewan as in Alberta, largely because of the absence of an adequate or readily accessible water supply. A large number of small schemes have been constructed in the southwestern part of the province, utilizing the runoff from the Cypress Hills. They are mostly individual flood-water schemes, built at a low cost, in connection with ranching operations. Some of them date back to the 1890's or earlier, but no accurate records seem to be available. The period of greatest activity seems to have been from 1908 to 1912. The Irrigation Branch of the Dominion Government reported in 1915 that there were some ninety-three projects in operation in this district, comprising some 28,000 acres, but that by no means all of this area had been actually irrigated. The area irrigated in 1914 was reported to be 11,959 acres. The area irrigated in 1918, which was a dry year, was reported to be only 4,511 acres.

Reservoirs must be constructed for the conservation of flood waters before any substantial improvement in the situation can be expected. Some progress has been made in this direction, particularly during the past two years, under the Prairie Farm Rehabilitation Act. Among them were two projects completed in 1936 on the Frenchman river. The Val Marie project, the larger of the two, provides storage capacity of 9.000 acre feet for the irrigation of 6,000 acres near Val Marie. The East End project has a storage capacity of 5,000 acre feet and will serve 2,500 acres near East End. A very large number of small irrigation schemes varying in size from a few acres up to several thousand, are being developed at this time through the assistance of the P.F.R. Act. The Natural Resources Department of Saskatchewan estimates that an area of fully 70,000 acres can be irrigated economically in southwestern Saskatchewan. (See map in Fig. 5.)

At least two very large schemes have been suggested in Saskatchewan. One would take water from the South Saskatchewan river near Elbow and serve a large area north and west of Moose Jaw. The other would divert water from the North Saskatchewan river near Rocky Mountain House, Alberta, utilize Buffalo and Sullivan lakes for storage, and irrigate a large area, possibly more than a million acres, between Rosetown and Saskatoon. They have received some preliminary field study dating back as far as 1912, but no complete survey or estimate has ever been made. It is certain, however, that they would be very expensive.

### The Present Trend in Irrigation Policy

Although irrigation is one of the oldest arts practised by civilized man, it must go through a pioneering stage in every new country. The half century, more or less, of its development in Canada has been largely of a pioneering nature. It is a significant fact that the highest development in agriculture, both in ancient and modern times, has been in countries where nature has failed to provide adequate rainfall and where it was necessary to supply the deficiency by the artificial application of water. And when agriculture was highly developed the other arts and sciences also flourished. Such was the history of the great valleys of the Euphrates, the Nile, the Ganges, and the Yang-Tse, where the civilizations of ancient times had their beginnings. They were all arid valleys dependent on irrigation for their success. It is an outstanding fact in history that the human race has never made material progress in countries where nature is too lavish in her support.

The first ventures in irrigation in a new country, as has been stated, have been small individual ones, constructed at very little outlay of money and as a rule serving a temporary purpose successfully. So also with the small community schemes. Then came the private or corporation schemes promoted for profit, nearly all of which met with financial failure, for reasons already stated. Then, for the past twenty years, practically all new development in Canada has been under the Irrigation District plan where the cost of construction and operation is assessed against the land on which the water is used. This seems to be the logical and democratic method for the administration of irrigation works, but up to the present time it has failed to recognize, except indirectly, one very important factor, and that is the general public benefit.

All irrigation construction in Canada to date has been based on the theory that the irrigated lands must bear all the costs. Within certain limitations this theory is correct, but in a broad sense there are many beneficiaries besides the particular land irrigated and the farmer who irrigates it. If a large section of country which in its natural state can provide only precarious support for a sparse population, can be converted into a wealth producing community supporting a large population, it becomes an asset to the whole country. The benefits are distributed through all the industries of the country and to all the people of the country, through increased ability to buy and sell and pay taxes.

Irrigation for big scale grain growing is not economically feasible. Where markets are available for higher priced crops such as fruits, sugar beets, peas and other vegetables, it is profitable. But its greatest value lies in the fact that with its aid comfortable homes can be established, feed for livestock can be produced, and the ravages of drought largely avoided.

Fig. 15—Concrete Drop near Picture Butte, Alta.

Further irrigation development by private capital probably cannot be expected in western Canada for the reason that its benefits are too widespread to be readily assessed. There is no practical way for an individual or corporation to levy and collect its costs. But it is a safe prediction that where a water supply is available and can be developed at reasonable cost its wealth producing value and possibilities of general benefits will be recognized and will result, sooner or later, in development under a policy whose aim will be to distribute the burden of cost more evenly over all who enjoy its economic benefits.

### Acknowledgments

This resumé of Fifty Years of Irrigation in Canada is largely historical rather than technical. It is a compilation of information gathered from many sources. Some of the contributions the author has used almost verbatim, and herewith expresses his thanks and acknowledgments to the following who have assisted him.

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# Communications Engineering

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### General Principles of Communications Engineering

The remarkable developments in electrical communication which have taken place in the last half century have been largely due to equally noteworthy progress made in this field in the search for new knowledge. As communications engineering is such a specialized branch, it seems desirable to outline a few of its theoretical principles (largely discovered during the past fifty years) before going on to the history of the developments in Canada during this period.

Communications engineering is usually considered as relating only to methods of communication by electrical signals. That telephony is a form of signalling may not be obvious because the telephone, like the teletypewriter, automatically translates its messages into code and back again into intelligible language. In the telephone code, the signal for each sound is made up of many component waves of different frequencies and of different relative powers instead of being composed of dots and dashes. As a matter of fact, the dots and dashes of the telegraph code, and of the teletypewriter code (which is composed of dots or dashes of five different lengths), may also be analysed into a wave code. Communications engineers are usually more interested in the wave frequencies than in the equivalent dots and dashes or speech sounds because the problem of transmitting irregular telegraph and telephone currents can be resolved into one of transmitting regular alternating currents of various frequencies. This leads to the consideration of two important principles involved in the transmission of information by electrical signals.

The first principle may be stated as follows: "In order that a received signal may be a 'true copy' of the transmitted signal all the component waves of the signal must be transmitted at equal velocities and with equal efficiencies." Except for very long distances, the time of transmission is so short for all frequencies, that effects due to differences in velocity are negligible, and the transmission characteristics of a line or piece of equipment may be

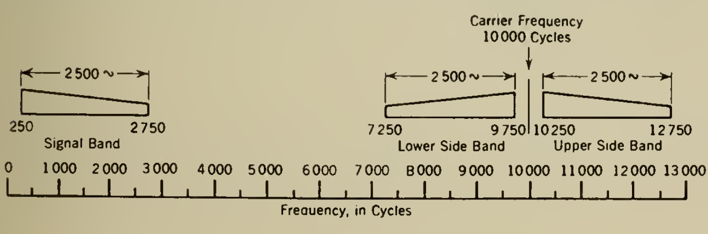


**Fig. 1**

judged from a curve showing the transmission efficiency of the line or equipment over the range of frequencies involved. For distortionless transmission, such a curve should be "flat," and the more nearly it approaches this ideal, the more exactly will the received and transmitted signals agree.

The second principle is as follows: "The amount of information that can be transmitted over a transmission system in a given time by means of a given type of signalling code, is proportional to the range of frequencies." At ordinary speeds, a telegraph message requires the transmission of frequencies ranging from zero to about 100 cycles. It might be thought that by doubling the speed of transmission the same range of frequencies could be used to transmit twice as much information. Actually, however, with the higher rate of transmission, the range of frequencies contained in the component signals is doubled, and will now extend from zero to about 200 cycles. Similarly, in the case of speech, if a phonograph record were run at twice its normal speed and the resulting sound transmitted, all the component frequencies would be doubled so that instead of extending from about 250 to 2,750 cycles they would extend from about 500 to 5,500 cycles, with the result that the frequency range utilized would be doubled.

Increasing the speed of transmission is not the only method, however, of getting more information per minute over a line. Another method is to transmit two or more messages simultaneously by using a different band of frequencies for each message. It should be noted that the total range of frequencies utilized is proportional to the number of simultaneous messages, so that in this case, also, the amount of information transmitted is proportional to frequency range utilized.

A simple example of this form of multiplex transmission is the composited telephone line, whereby telegraph and telephone currents may be transmitted simultaneously over the same line. A selective circuit known as a composite set separates the low telegraph frequencies (approximately zero to 100 cycles) from the higher frequency telephone currents (250 to 2,750 cycles, approximately).

More extensive applications of multiplex transmission have been made possible by the development of processes for shifting the bands of frequencies representing telegraph and telephone signals to any desired position in the frequency scale before transmission, and for shifting them back to their normal position after transmission. These developments have led to the form of multiplex transmission known as carrier telegraphy and telephony.

For wireless transmission, the use of high frequencies in place of the original dot-and-dash or voice frequencies is essential, and to prevent interference, different radio stations in the same area use different radio frequencies. Each radio receiver is able to select one programme or message from the many by means of tuned circuits, and translates the high frequencies back to the original signal frequencies.

The translation of a band of signal frequencies to a new position in the frequency scale is known as modulation.

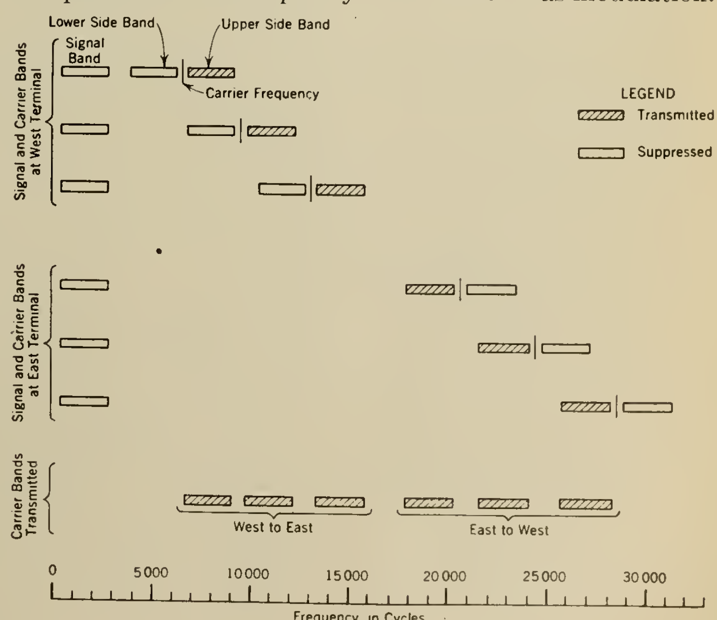


**Fig. 2**

This process combines each frequency of the signal band with a new frequency called the carrier frequency, which is generated for this purpose. From the combination there are obtained two new bands of frequencies, one above and one below the carrier frequency, as shown in Fig. 1; these frequency bands are known as the upper and lower side bands. Each frequency of the upper side band is equal to the sum of a corresponding signal frequency and the carrier frequency, and each frequency of the lower side band is equal to the difference between its corresponding signal frequency and the carrier.

One speech sound differs from another in the relative amounts of power in its different component frequencies. For simplicity, a signal in which the power decreases uniformly towards the high frequency end of the band is illustrated, the height of the band at each point indicating the relative amount of power at each frequency. It will be seen that the upper side band represents the signal band simply shifted up the frequency scale while the lower side band corresponds to the signal band raised up the scale and inverted.

The converse operation to modulation is called demodulation or detection, and translates the side band frequencies back to the original signal frequencies. Demodulation can derive the signal frequency band either from the upper or lower side band, or from both, and does so by combining the side band frequencies with the carrier frequency so as to obtain sum and difference frequencies as in modulation. The band of difference frequencies will be identical with the original band of original frequencies.

To avoid using a greater range of frequencies than necessary, it is customary, in carrier telephony, to transmit only one side band. Figure 2 illustrates the various frequency bands involved in the type C-4-S carrier telephone system, showing which side bands are suppressed and which are transmitted. In carrier telegraphy both side bands are transmitted because the frequency bands are so narrow that the cost of providing sufficiently selective circuits to pass one band and suppress the other is not justified. Figure 3 illustrates the progress which has been made during the past fifty years in adding to the number of communication channels available over one pair of wires

In the transmission of electrical signals by wire or by radio each method has certain characteristics which make it more suitable for some purposes than for others. Wire transmission is essentially more private as the signals follow the conductors from the sending to the receiving station, whereas radio signals are radiated into space and can be picked up at a large number of receiving stations. On account of this, radio transmission is particularly suitable where publicity is desired, as in the case of an SOS call and for the broadcasting of entertainment and advertisements. Secrecy can be obtained in radio transmission by using a private code. In radio telephony, the voice frequencies can be converted into a private code of frequencies and the result is popularly known as "scrambled speech." Radio must also be used where either or both stations are mobile. With wire transmission, switching centres can be conveniently introduced for establishing connection between any two of a large number of stations. It is only necessary to compare the fifteen lines needed to completely interconnect half a dozen points on a sheet of paper with the half dozen lines needed to connect them to one central point, to realize that a large saving in communication channels can be obtained with switching facilities, and the savings increase with the number of points to be interconnected.

With both forms of transmission, the signals become weaker as they travel away from the transmitting station, but in the case of wire transmission over land, repeaters can be conveniently introduced at intermediate points to amplify the attenuated signals and thus restore their original strength. It requires much less power to periodically amplify the signal in this way than to provide sufficient power at the transmitting station to give the same signal strength at the receiving end without repeaters. As an example to illustrate this, let us assume that in travelling 100 miles the power of a signal decreases to one tenth of its initial value, and let us consider a transmitting and receiving station 600 miles apart. If a signal is transmitted with a power of 1,000 watts, the power will fall to 100 watts at the end of the first hundred miles, to 10 watts at the end of the second hundred miles, and so on. Thus when it arrives at the receiving station, its power will be only a thousandth of a watt, or one milliwatt. By installing a repeater every hundred miles that will multiply the power of the signal by ten, it is only necessary to transmit ten milliwatts in order to receive one milliwatt, the power of the signal being alternately reduced to one milliwatt in travelling a hundred miles and then raised to ten milliwatts again. By using repeaters, therefore, the total expenditure of power is reduced from a thousand watts to a small fraction of a watt (10 milliwatts at the transmitting station

| Year | Type of Communication | Graphical Presentation | Number of Channels: Single Morse Telegraph | Duplex Telegraph | Two-Way Telephone | Total |
|---|---|---|---|---|---|---|
| 1837 | TELEGRAPH (One Channel Transmitting in One Direction at a Time) | | | | | 1 |
| 1887 | TELEGRAPH (Two Duplex Channels, One on each Wire) TELEPHONE (One Channel Two-Way Transmission) | | | 2 | 1 | 3 |
| 1937 | Type 50-*B-H* Carrier Telegraph System | West to East · East to West | | 12 | 1 | 13 |
| | — or — V.F. Carrier Telegraph on Type *C4N* Carrier Telephone | East to West · West to East | | 38 | 1 | 9 |
| | — or — Type *C4S* Carrier Telephone | East to West · West to East | | 2 | 4 | 6 |
| | Frequency Scale | 0 5 10 15 20 25 30 — Frequency, in Kilocycles | | | | |

Fig. 3

and 10 milliwatts at each of five repeater stations, making a total of 60 milliwatts).

It may be of interest at this point to explain the communication engineer's unit of transmission loss and gain, known as the decibel and abbreviated as db. In this unit a line which delivers one tenth of its power input causes a loss of 10 db. and an amplifier, which has a power output of ten times greater than its power input, introduces a gain of 10 db. Expressed in this unit, therefore, the transmission loss for each hundred miles and the offsetting transmission gain at each repeater, for the example which we have just considered, is ten decibels. Thus the transmission loss for the 600 miles without repeaters is 60 db. and with five repeaters is reduced from 60 db. to 10 db.

One other comparison should be noted between wire and radio transmission, namely, the means which are available for obtaining more than one communication channel between two points. With wire transmission it is possible to furnish a separate circuit for each channel and to use as many circuits as desired. If more are required than can be conveniently run as open wire, or if it is desired to place the conductors underground, multi-conductor cables can be used. The use of carrier frequencies for obtaining additional channels is an alternative to the use of additional circuits and permits savings in capital expenditure on long distance circuits. With radio transmission, the use of different frequency bands is the only means of obtaining multiple channels.

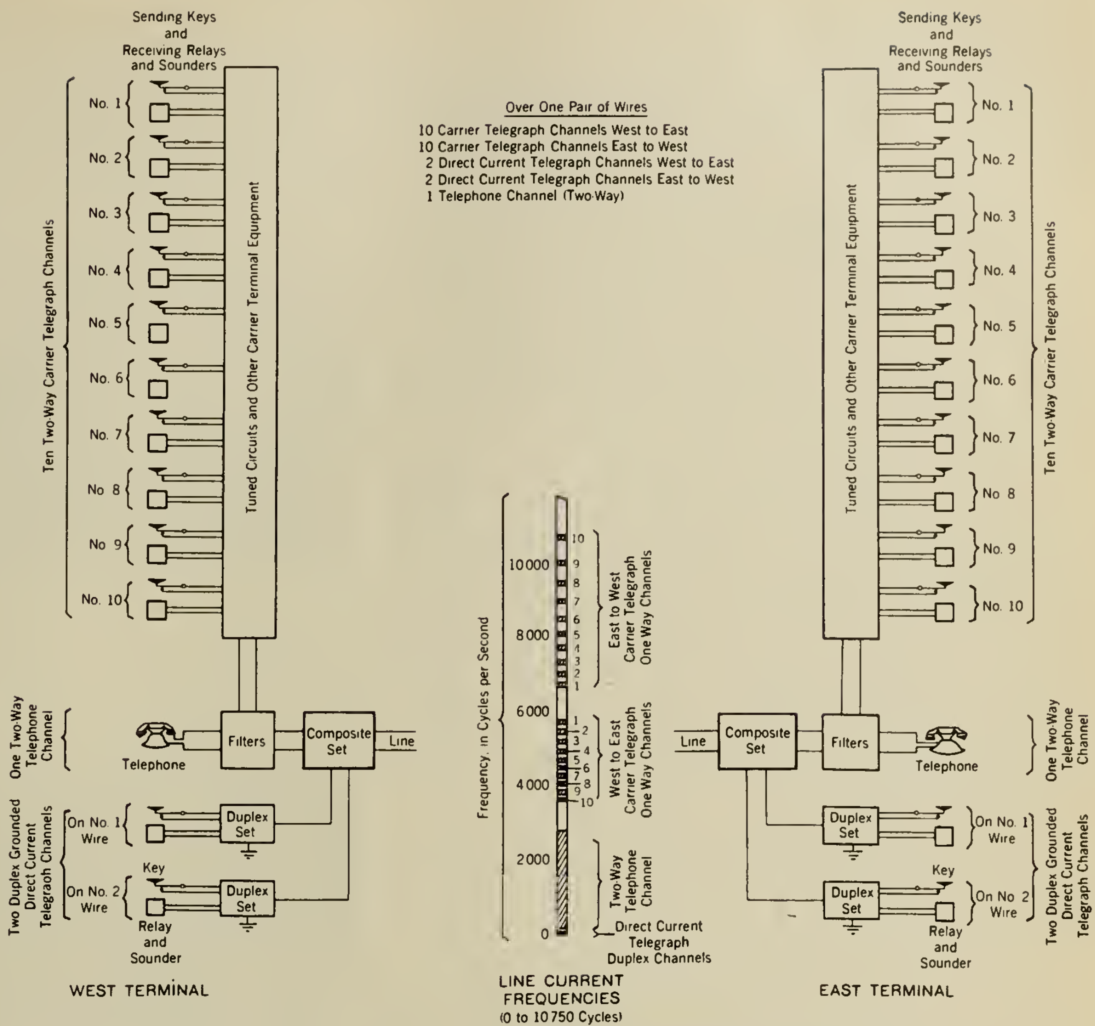


**Fig. 4—Diagram Illustrating Open Wire Carrier Telegraph System (Type 50-B-H).**

The total range of frequencies used for radio transmission has been extended to much higher frequencies than for wire transmission, it being now practicable to use frequencies as high as from three to five hundred megacycles. The range of frequencies used for carrier transmission over the usual type of open wire circuit has not until recently extended beyond about 30,000 cycles. Recent developments in this field, however, have made it practicable to use frequencies as high as about 110 kilocycles on the usual type of open wire and cable, and by the use of a special type of transmission line known as a coaxial cable, consisting of a central wire enclosed in a tubular return conductor, it will be possible to extend the upper limit for practicable wire transmission to at least 1,000 kilocycles.

### Wire Telegraphy

The year 1887 marked the fiftieth anniversary of the invention of the electric telegraph by Cooke and Wheatstone in England and by Morse in America, and at a meeting of the Society of Telegraph Engineers and Electricians (later to become the Institution of Electrical Engineers) held in January of that year, Sir Charles Bright reviewed the history of land and submarine-cable telegraphy during the fifty years then completed. It is interesting to take note of a few of his remarks that throw a light on the state of the art in 1887, at the end of *his* fifty years and at the beginning of *ours*.

". . . on investigating the practical application of electricity for general use of mankind during the last half-century, we find nearly the whole of the work done and capital invested has been connected with electric telegraphs, at all events until 1878, since when a material movement has taken place in the development of electric lighting and telephones . . . the beautiful and rapid instrument of Sir C. Wheatstone and Mr. Stroh now used at the Post Office, the latest speed of working which I am informed by Mr. Preece is four hundred and thirty-five words per minute . . . making a total of 107,000 miles of submarine communication with all the important parts of the world in which more than £37,000,000 capital is invested . . . Duplex telegraphy as applied to cables has been brought to a high degree of perfection judging from results obtained on the Mackay-Bennett cables recently laid across the Atlantic. . . At the present time the Post Office have no less than 153,153 miles of wire used for commercial purposes with 5,097 offices . . . Nor have I been able to refer to telephones which may be regarded as a branch of the telegraphs."

Turning now to the field of Canadian communications, the completion of Canada's transcontinental railway line in 1885 by the Canadian Pacific Railway Company provided in addition to the railway, a transcontinental telegraph line as a link between the east and west. This line was opened for commercial business the following year, and in December, 1886—just about a month before the meeting of the Telegraph Engineers in Westminster, England, from which we have quoted—the inauguration of this "all red" route was commemorated by the following telegraph message from New Westminster on the Pacific to old Westminster in London:

> December 20, 1886—New Westminster, British Columbia, sends greetings to old Westminster, 12.20 p.m. weather cloudy, light rain, thermometer 44 degrees, above. What is weather with you? We are working with cable office in Canso over circuit of 4,600 miles.

In her reply old Westminster sent the compliments of the season to her sister namesake and remarked that the weather was heavy and foggy with the temperature at about 32 degrees.

About two years later, when a direct transcontinental line reached Fredericton, New Brunswick, communication from coast to coast was still so novel that this event also was commemorated by an interchange of greetings, which took place on February 20th, 1889, between the mayors of Vancouver and Fredericton. Said the Mayor of Vancouver, with civic pride and perhaps foreseeing the television of a future age; "Wish we had transcontinental telescope as well as telegraph so you could take a peep at our gardens and fields this morning. Take my word they look glorious."

Said Fredericton's mayor, knee deep in eastern Canada's snow, "On receipt of your telegram several of the audience fainted and the few remaining got up and left for Vancouver."

At this time the transcontinental line was of iron, No. 6 BWG gauge, and local lines were of No. 9 iron wire. In 1898, a copper wire was strung from Montreal to Vancouver. This wire weighed 300 lb. per mile, and was drawn in Canada.

In 1902, the culmination of a long felt desire for an "all red" route for British Empire communications was seen in the completion of a cable between Canada and Australia by means of which communications could be transmitted to different parts of the Empire without passing through foreign territory. The British, Canadian, Australian, and New Zealand governments formed the Pacific Cable Board for the purpose of operating the cable, and the land wire facilities for transmission across Canada were supplied by the Canadian Pacific Railway Company. The completion of this cable in November 1902 was made the occasion of the first around-the-world telegrams ever transmitted. Two messages were sent, one to the east and the other to the west, and were addressed to the Governor General from Sir Sandford Fleming, who had played a great part in bringing about this development of Imperial communications. By 1910 the traffic over this "all red" route was so great that the Pacific Cable Board found it necessary to lease a wire from the Canadian Pacific for its own exclusive use.

The extensive programme of railroad construction involved in building the two additional transcontinental lines which Canada now possesses was accompanied, of course, by associated telegraph lines. In 1915, the Canadian Northern Railway obtained control of the Great North Western Telegraph Company, and combined its own telegraph system with the G.N.W. Company's under the name of the latter. In 1918, when the Canadian Government took over the Canadian Northern and the Grand Trunk Pacific Railways, it also took over their telegraph systems, forming what is now the Canadian National Telegraphs.

Great as had been the growth of Canada's telegraph network in the early 1900's, making it in proportion to her population one of the most extensive in the world, the traffic between the larger cities began to tax the capacity of the available lines. Many operators started using typewriters, so as to be able to receive at high speeds more easily, and before long the use of a typewriter became compulsory on commercial wires.

The printing telegraph was first put into service by the Canadian Pacific Railway Telegraphs between Montreal and Toronto in 1912. Its use was gradually extended during the following years, until now the printer is in service between all important Canadian cities.

The post-war era of prosperity which began for Canada about the year 1922 and ended about 1929 brought to the telegraph systems more traffic than their lines could handle. Means were available, however, in the newly developed carrier telegraph system, for obtaining additional message channels without constructing new lines, and both the Canadian National and the Canadian Pacific Railways took full advantage of this new system. The first installation to be put into operation was a circuit between Montreal and Toronto for the Canadian National Telegraphs, which was opened in April 1927. By the end of 1927 the Canadian National, and by the end of 1929 the Canadian Pacific, had carrier circuits in operation from Montreal to Vancouver. Since a carrier telegraph circuit can also be used as a high grade telephone circuit, both companies installed telephone repeaters as well as the carrier equipment and thus obtained long distance telephone circuits for their official business.

At about this time telephone circuits began to be used for transmitting radio programmes to distant radio stations, and the two large telegraph systems found themselves in the strategic position of having transcontinental circuits available that could be readily arranged for this service. The success of the Jubilee Broadcast in 1927 (of which more will be said under Radio Telephony) showed the possibilities in this field, and from that time the telephone and telegraph companies have both had a share in supplying lines for transmitting radio programmes.

### Wire Telephony

Alexander Graham Bell's early experimental work at Brantford, Ontario, in which speech was first transmitted over distances measurable in miles rather than feet was carried on in the summer of 1876. In 1887, therefore, the telephone was eleven years old, and networks of telephone wires were rapidly spreading over all large towns and cities. One of the most important problems engaging the attention of telephone engineers was the development of a satisfactory multi-conductor cable as a substitute for open wire construction, as the congestion of these lines threatened to limit the growth of the industry. With a view to developing the most suitable type of cable, a conference was held by representatives of the various American companies in 1887, and a specification for a standard cable known as Conference Cable was issued in the following year. The largest size of this cable contained fifty pairs of 18 gauge conductors, the conductors being wrapped with cotton, twisted in pairs, and cabled in reverse layers. The cable thus formed was impregnated with an insulating compound and pulled into a lead pipe having an outside diameter of two inches. The lead was alloyed with 3 per cent tin, as experience had shown this alloy to have less tendency to crystallize and crack, and to be less subject to corrosion than commercially pure lead.

During the next few years, trials were made of dry core cables using paper insulation without any filling, or sealing, compound. These tests showed that the lead sheath, if properly sealed at the ends, could be relied on to exclude moisture, and in 1891 dry core cable was adopted as standard in place of the original "Conference Cable." The new specifications also reduced the conductor size from 18 to 19 gauge and specified a capacitance of 0.080 mf.

per mile between any one conductor and all other conductors grounded to the sheath, which was approximately equivalent to a mutual capacitance of 0.054 mf. per mile between the conductors of each pair. Cable with these characteristics came to be known very definitely as "standard cable" and the transmission efficiencies of later cables were compared with that of standard cable as a reference standard. This gave rise to the transmission unit known as the "mile of

**Fig. 5**
**Telephone Call Bell Switch**
**The Equipment for Six Telephone Lines of the First Exchange in Canada (Hamilton, Ontario, 1878).**

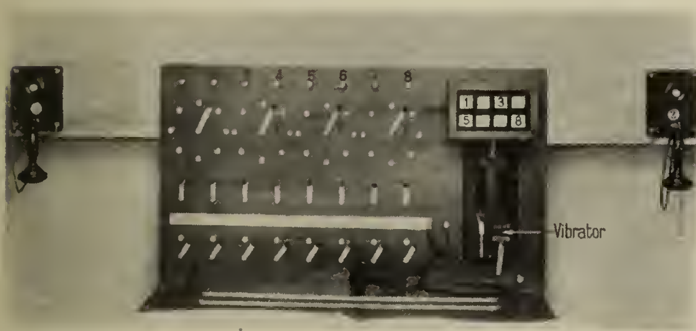


**Fig. 6—Typical 8-Line Telephone Switchboard of about 1880.**

standard cable" which remained in use until the adoption of the transmission unit now known as the decibel. The two units are approximately equivalent for average voice frequencies, one mile of standard cable having a transmission loss of 1.056 db. at 800 cycles.

In 1892 the largest telephone cables contained a hundred pairs and were 2½ in. in diameter. By 1901, cables of the same diameter were available containing 300 pairs of 19 gauge conductors.

The maximum outside diameter of telephone cables has been fixed at 2⅝ in. as this is the largest size that can be accommodated in existing underground ducts, and also because this is about as large a cable as can be satisfactorily handled by present methods. In order to accommodate more pairs it has been necessary to use smaller gauge conductors. The first of these was a 606-pair, 22-gauge cable which was introduced in 1902. This was followed by a 909-pair, 22-gauge cable in 1913, a 1,212-pair, 24-gauge cable in 1915, and an 1,818-pair, 26-gauge cable in 1927. The largest of these to be made in Canada up to the present has been the 1,212-pair, 24-gauge cable, the production of which was commenced in this country in 1921.

In 1907 research work was undertaken with the object of finding a substitute for the lead-tin alloy used for the cable sheath that would be equally satisfactory and less expensive. After extensive field trials, a lead-antimony alloy was adopted. In Canada the lead-antimony alloy has been in use for new cables since 1916.

In the early nineties, telephone companies encountered a serious difficulty as a result of the introduction of electric street railways. Until that time, although two-wire circuits were becoming standard practice for long distance lines, the local exchange lines were single wires, the earth being used as a common return conductor. The heavy earth currents of the street railways, however, caused so much noise on the telephone circuits that it became necessary to convert the grounded single wires to two-wire circuits.

Switchboards arranged to operate with a common central office battery in place of individual batteries at the subscribers' premises were introduced in Canada in the early 1,900's. Queen Exchange, Ottawa, was probably the first Canadian exchange to have a common battery switchboard, and this was cut into service in 1900. Automatic systems whereby calls can be established without the services of an operator were also being introduced at about this time. One of the first automatic offices in Canada was installed in Edmonton in 1905 and was of the Strowger step-by-step type.

Important improvements in telephone transmission were made possible by the invention of the loading coil in 1900 by Pupin. It had been shown by Heaviside that by adding inductance to a telephone circuit the transmission loss caused by the mutual capacity between the conductors could be greatly reduced, and Pupin's invention of the loading coil provided a practicable means of adding this inductance. The application of loading to open wire circuits permitted the distance over which long distance service could be provided to be approximately doubled. Before the introduction of loading, the longest toll circuit over which commercial service could be given was about 1,000 miles long. The development of loading allowed the line to be extended to about 2,000 miles. For these long distance circuits, it was necessary to use No. 8 gauge copper. The advent of telephone repeaters and of carrier telephony caused the loading of open wire circuits to be abandoned,

**Fig. 7—Three Sections of Winnipeg's Switchboard in 1896, with one hundred Subscribers' Lines per Section.**

and smaller gauge wires to be used, but loading is still an important aid to telephone transmission over cable and is used both for toll cables and exchange area cables.

The earliest loading coils used a core of fine iron wire. Greatly improved coils were made possible, however, by the introduction of the compressed powdered iron core in 1916. The development of the permalloy dust core, which was introduced in 1927, has greatly reduced the size and cost of loading, and a still further reduction in the size of loading coils has now been made possible by the development of a new molybdenum permalloy.

Although loading had extended the range of telephony, it was not until the vacuum tube telephone repeater had been developed that continent-wide service became practicable. The telephone repeater became available in 1913, and two years later transcontinental service was inaugurated in the United States.

The first telephone repeaters used in Canada were installed at Kingston in 1917, and the first step towards a Canadian transcontinental circuit was taken in 1921, when the Telephone Association of Canada was formed. This association was composed of members representing the seven major telephone systems in the Dominion, and at its first annual meeting a committee was formed to investigate the possibility of providing transcontinental service over an all-Canadian circuit. The report of the committee indicated difficulties in providing lines through the Rockies, around Lake Superior, and through a stretch of almost uninhabited country extending east of Quebec to the boundary of New Brunswick. Further discussion of the project took place at later annual meetings, but little progress was made until 1928. In that year an engineering study of the problem was begun and two years later, in 1930, work on the undertaking was started. Finally, on January 25th, 1932, the Trans-Canada Telephone System was formally opened by Lord Bessborough.

During the interval that had elapsed between the time that transcontinental telephony had been made possible by the development of the voice-frequency telephone repeater, and the time that the layout of the Trans-Canada Telephone System was begun, the technique of long distance

Fig. 8—Telephone Repeater Equipment used in Transmitting Radio Programmes for Network Broadcasting.

telephony had been considerably changed by the development of the carrier telephone system. Several types of carrier telephone systems have been developed, but the one in most general use is the Type C. This system provides three carrier frequency channels in addition to the regular voice-frequency channel on one pair of wires, and utilizes a maximum frequency of about 30,000 cycles. At each repeater station it is necessary, of course, to amplify the carrier-frequency currents as well as the voice-frequency currents. At these points, the carrier-frequency currents are separated from the voice-frequency circuit, a voice-frequency telephone repeater being used for the voice-frequency circuit, and a carrier repeater consisting of two amplifiers with electrical filters to separate the two directions of transmission, being used for the three carrier channels as a group. After amplification the carrier and voice-frequency currents are again brought together for transmission over another section of line.

With carrier-frequency currents, the tendency for currents in one circuit to induce currents in nearby circuits is greater than at voice-frequencies. For this reason new transposition systems employing transpositions at more frequent intervals are necessary to prevent crosstalk. It is also desirable to reduce the spacing between the two wires of each pair from 12 in. to 8 in., at the same time increasing the spacing between different pairs on the same crossarm.

The carrier telephone system is used extensively for the Trans-Canada Telephone System and on a transcontinental call, transmission is at carrier frequencies for nearly the entire distance. The total length of the Trans-Canada line is about 4,200 miles, of which it was necessary to completely rebuild about 2,000 miles and to carry out pole work for carrier transpositions on some 1,500 miles.

Turning now from long distance to local telephony, a major change that has taken place in recent years is the gradual superseding of the manual system by the dial system in urban areas. Beginning, as has already been mentioned, with Edmonton in 1905, most of the larger cities of Alberta and Saskatchewan had dial telephones before the war, and soon after the war Manitoba also began to adopt the dial system. In Ontario and Quebec, the change to dial operation began in Toronto with the cutover of Grover Office in July 1924, and in Montreal with the cutover of Plateau Office in January, 1925. The Maritime Provinces and British Columbia have also adopted the dial system in some of their cities.

The change to dial operation is still in progress and has begun to penetrate rural areas as well. Various types of equipment, which can be left unattended except for occasional visits. have been developed for use in such areas.

| 1887 | | 1935 | |
|---|---|---|---|
| City | Telephones per 1,000 population | City | Telephones per 1,000 population |
| Winnipeg | 24.4 | Washington | 358 |
| Toronto | 15.6 | Vancouver | 280 |
| Ottawa | 12.8 | Chicago | 252 |
| Montreal | 10.9 | Toronto | 246 |
| Washington | 7.0 | New York | 206 |
| New York | 5.0 | Ottawa | 189 |
| Chicago | 5.0 | Montreal | 162 |
| Glasgow | 3.9 | Winnipeg | 149 |
| London | 0.8 | London | 96 |
| | | Glasgow | 52 |

### Public Address Systems

With the facilities for increasing the power of telephone currents, made possible by the vacuum tube amplifier, it was not long before loud speaking telephones, capable of converting the amplified electrical energy into amplified sound, was developed. One of the earliest demonstrations in Canada of the utility of loud speaking equipment was on the occasion of President Harding's visit to Vancouver in July 1923, while returning from Alaska. During this


**Fig. 9—Route of Trans-Canada Telephone System, showing Terminal and Repeater Points.**

visit he delivered an address to a large gathering in Stanley Park and by the use of a public address system the entire audience was able to hear him clearly.

Loud speaking equipment was again used during Lloyd George's visit to Montreal in October of the same year, making it possible for an audience of 11,000 people to hear him without difficulty when he spoke at the Mount Royal Arena.

Though novel in 1923, loud speaking equipment soon became another commonplace facility of communication engineering, the use of which was to be expected whenever conditions made it desirable. Many permanent installations have been made in large auditoriums, churches, and hotels.

An outstanding example of a hotel installation is that of the Royal York Hotel in Toronto, which until eclipsed by the one at the Waldorf Astoria, was the largest and most up-to-date installation in the world. In each of 1,600 bedrooms a loud speaker is provided, with switching facilities by means of which guests may listen to either of two programmes. These may be received by radio or by wire from an outside point, or they may be music or speeches originating in one of the public rooms of the hotel. In addition, all large public rooms are equipped with concealed loud speaking equipment permitting amplification of a speaker's voice so that he may be clearly heard, no matter how large the gathering. There are microphone outlets, also, in all the public rooms permitting speeches or music originating therein to be picked up both for the hotel loud speakers and for radio broadcasting.

*The Recording and Reproduction of Sound*

The problems involved in designing mechanisms for recording and reproducing sound are quite similar to those involved in the designing of telephone transmitters and receivers, and communication engineers have naturally taken an interest in this allied field. When the vacuum tube amplifier became available and led to the introduction of electrical recording and reproduction, the two arts became even more alike, so that to-day the recording and reproduction of sound is usually considered as a branch of electrical communication.

After loud speakers capable of high volume reproduction with good fidelity had been developed, communication engineers began to study the problem of recording and reproducing sound in synchronism with the photographing and projecting of motion pictures, with the object of making possible the production of talking motion pictures. Success was finally achieved and the first theatres to show the resulting sound pictures did so before capacity audiences.

In Canada, the first theatre to be equipped for showing the new "talkies" was the Palace Theatre in Montreal, which opened with sound pictures on September 1st, 1928. Many more installations quickly followed and it was not long before silent films practically disappeared.

**Fig. 10—Amplifying Equipment for Public Address and Music Reproducing System, Royal York Hotel, Toronto.**

Sound recording equipment for the making of sound pictures has also been installed in Canada by such organizations as the Canadian Government Motion Picture Bureau and the Associated Screen News Limited.

WIRELESS TELEGRAPHY

Marconi applied for his first British patent on wireless telegraphy in 1896. Three years later, he succeeded in transmitting messages across the English channel. After further experiments, he succeeded in spanning a distance of 150 miles, and becoming convinced that the curvature of the earth would not prevent wireless communication over still greater distances, he boldly decided to make an attempt at spanning the Atlantic. In 1900 the erection of a powerful transmitting station at Poldhu in Cornwall was begun and in December 1901 he was successful in receiving faint signals from that station in Newfoundland.

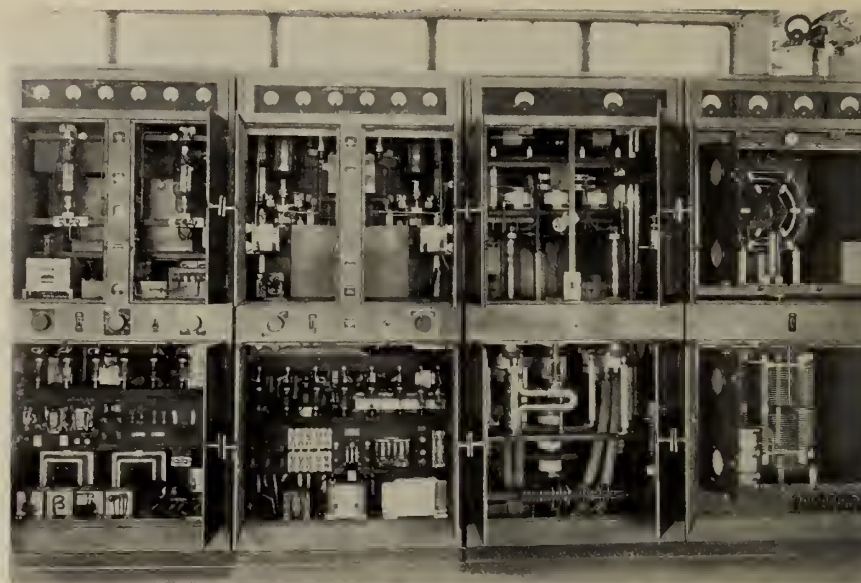

Fig. 12—Radio Transmitting Equipment for a Modern Broadcasting Station.

Experiments between England and Newfoundland were stopped, however, due to a notice from the Anglo-American Telegraph Company to the effect that they had a monopoly of telegraphic communication in Newfoundland. The Canadian Government at once invited Marconi to Canada and in February 1902 an agreement was made, and ratified by the House of Commons, whereby a sum of £16,000 was granted for the erection of a station on the Canadian coast on condition that the wireless rates for telegrams across the Atlantic should not exceed 10 cents a word. Quoting from R. N. Vyvyan's "Wireless over Thirty Years":

Fig. 11—Edmonton heard the Diamond Jubilee Broadcast by means of a Public Address System.

"The Canadian Government by this far-sighted and public spirited action in the cause of technical advancement and public welfare, played a very large part in bringing about the remarkable developments in long distance wireless communication which took place during the next few years, because it was at the Canadian station erected at Glace Bay, Cape Breton Island, that most of the experimental work that led to a regular transatlantic service originated, and it was from this station that the first wireless transatlantic messages were successfully transmitted."

In October, 1902, the construction of the Glace Bay station was completed, and the first messages successfully transmitted in December of that year. Transmission was not sufficiently reliable, however, for commercial service and in 1904 a more powerful plant was installed, but results were still disappointing. For another three years, experiments were carried on, and further improvements made, until success was finally achieved and transatlantic service opened to the public in 1907.

For the period of the war, the British Admiralty closed down wireless service between England and Canada so as to prevent enemy countries from picking up information transmitted over this channel. After the war, development centred at first on the vacuum tube and its application to transmitters and receivers. One of the first long distance circuits to use vacuum tube transmitters for commercial radio telegraphy was the one between Canada and Great Britain. The transmitting set at Glace Bay used forty-eight 500-watt tubes in parallel when this circuit was changed over from damped wave "spark" transmission to continuous wave operation using vacuum tubes.

The next important development was the Imperial short wave beam system. The value of a chain of wireless stations throughout the Empire had been pointed out as early as 1908 in an article entitled "Imperial Wireless Communications" by R. N. Vyvyan, which was published in *The Times*. At the Imperial Conference held in 1911, the proposal to develop an Imperial wireless telegraph system was discussed and after the scheme had been investigated by several Parliamentary committees, a contract with the Marconi Company for an "Imperial Wireless Chain" was ratified by the British House of Commons in August, 1913. The war, however, led to the cancellation of this contract.

After the war, new proposals were made by the Marconi Company and at the Imperial Conference of 1921 it was agreed that a chain of Imperial stations should be proceeded with as rapidly as possible. Questions of State versus private ownership prevented a definite agreement being reached until 1924, and in the meantime, the development of the short wave beam system changed the picture. To determine the possibilities of this system, Marconi had erected a short wave beam transmitting station at Poldhu, and in 1923 and 1924 he carried out a series of tests between this station and the yacht *Elettra* and also between Poldhu and stations in Canada and Australia. During these tests, signals were clearly received in Montreal on a single tube receiver with little or no aerial. The success of these experiments led the Marconi Company to open negotiations with the British Government with a view to using the Beam System for the Imperial Chain, and in

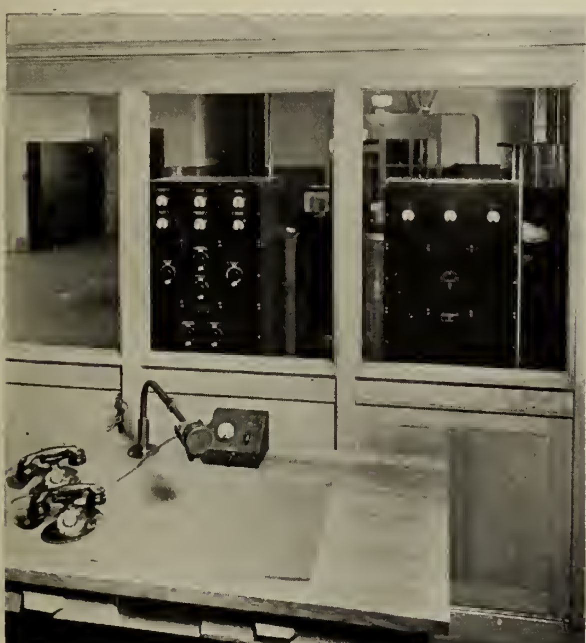

Fig. 13—Police Radio Transmitter.

July, 1924, an agreement was finally reached and a contract made with the British Post Office for Imperial Wireless Communications by means of the short wave beam system. Canada's links in this highly successful Imperial Chain were opened for service between Canada and England, and between Canada and Australia, in October, 1926, and in July, 1928, respectively.

### Wireless Telephony

Besides being the first to transmit speech by wire, Alexander Graham Bell was also the first to demonstrate "wireless" telephony. He accomplished this by causing the sound vibrations at the transmitting point to modulate a beam of light; at the receiving point, by making use of the property of selenium whereby its resistance varies with varying illumination, he obtained a varying current for operating a telephone receiver. His experiments with this invention, which he called a Photophone, were made in the years 1878-1880. It is interesting to note that in recent years practical use is being made of beam transmission, and also of radio waves so short as to be termed "quasi-optical," thus bringing modern radio closer to Bell's early form of radio transmission.

The first radio broadcast in Canada, and sometimes claimed as the first in the world, was originated by the Canadian Marconi Company at Montreal in May, 1920, as a demonstration for a meeting of the Royal Society of Canada which was being held at the Chateau Laurier in Ottawa. The first United States licenses for broadcasting stations were issued in September, 1921, and the winter of 1922-23 saw radio broadcasting assume the proportions of a "craze." Like all such outbursts of enthusiasm, however, this one had its day, after which the new industry settled down to steady progress.

At first the radio listener was most interested in "logging" as many, and as distant stations as he could. After the novelty of radio reception began to wear off, however, its entertainment value began to be more fully appreciated, and the public began to ask for high quality reception of entertaining programmes at loud speaker strength. This led to rapid improvement of radio receivers and transmitters, and was also one of the influences that resulted in network broadcasts whereby high grade programmes could be given to continent-wide audiences.

Fig. 14—Police Radio Automobile Receiver.

The first network broadcast in Canada was given in December, 1923, when a telephone circuit was used to link Ottawa and Montreal for a programme sponsored by the Canadian National Railways. An early network broadcast which was given considerable publicity as the first "International Broadcast" took place on January 1st, 1927, when a programme offered by the Victor Talking Machine Company of the United States and of Canada was broadcast from a network of twenty-five American and three Canadian stations, the latter being at Montreal, Toronto and Ottawa.

On July 1st of the same year, as a part of the celebrations for the Diamond Jubilee of Confederation, a Dominion-wide broadcast "From Sea to Sea" carried the first sounds of Canada's Peace Carillon, and a programme of speeches and music to all parts of the Dominion and to many foreign lands. The radio transmitting stations used for this broadcast were tied together by a network of lines made available by Canada's various telephone and telegraph systems, all of which gave their full co-operation to make the tremendous undertaking a success.

With the growing use of wire lines for linking together radio broadcast stations, it was natural that telephone companies should also consider the possibility of using radio links in their telephone networks, where conditions were unfavourable for building wire lines. The first radio telephone link to be put into service in Canada was one between Campbell River on Vancouver island and Powell River on the mainland, by the Northwest Telephone Company (a subsidiary of the British Columbia Telephone Company). This link was opened in June, 1930, and handled between twenty and forty calls a day until replaced by a submarine cable in July, 1931. The success of this first radio link led to the installation of a number of others, with the result that to-day many isolated points on the rugged coast and in the mountainous hinterland of British Columbia have telephone communication with the outside world. Besides its use by telephone companies, for public service, point to point radiotelephony has also been put to private use by such interests as pulp and paper, mining and aerial transport companies, operating in the new Canada lying beyond the end of steel rail and copper wire.

Commercial telephone service between Europe and United States was initiated in January, 1927, over a long-wave radio circuit, and was extended to Canada in October of the same year. This service was supplemented in the following year by additional short-wave channels. The success of direct short-wave radio telegraph service between Canada and Great Britain, which had been initiated in October, 1926, led to the desire for similar direct telephone service, and on January 29th, 1931, although not ready for commercial service, a direct transatlantic telephone circuit was made available by the co-operation of the British Post Office, Imperial and International Communications Ltd., Canadian Marconi Company and the Bell Telephone Company of Canada for a joint meeting of the Engineering Institute of Canada in Montreal and the Institution of Electrical Engineers (the same body which in 1887 had been known as the Society of Telegraph Engineers and Electricians) in London, England. Although transmission was poor, due to an exceptionally severe atmospheric disturbance, the meeting marked another step in the progress of communications engineering in Canada.

The transatlantic circuit was not opened for commercial service until July 11th, 1932. Seeing that the Imperial Conferences of 1911 and 1921 had played an important part in initiating the plan for an Empire-wide system of Radio Communications, it was rather appropriate that one of the first uses of this new telephone link in the Imperial Chain should be to join together Canadian and British broadcast stations for a transatlantic broadcast of the opening of the Imperial Conference at Ottawa, July 21st, 1932. That year gave us also the first of those Christmas Day Empire Broadcasts which, during the closing years of King George V's reign, brought at each Christmastide to every listening home in the Empire, feelings of common fellowship and goodwill—the strongest bond of our Empire—and closed each year with the voice of the King.

### Television and Telephotography

A review of developments in electrical communication would not be complete without some mention of telephotography and television. The transmission of pictorial or visual images requires the representation of light and shade variations over an area by current variations over an interval of time. To do this, the area is subdivided into narrow strips and by a process known as scanning, the variations of light and shade along each strip in turn are translated into variations of an electric current. In telephotography, one scanning is sufficient, but in television, where the visual image changes from moment to moment, the scene to be transmitted is scanned repeatedly so as to give the illusion of motion by a rapid succession of still pictures.

Telephotography has been in commercial use since about 1925 and television has begun to emerge from the experimental stage. One of the difficulties in television is the wide band of frequencies required. For radio transmission, the wide bands required are only available at what are known as ultra-high frequencies. For wire transmission, a special type of transmission line known as a coaxial line will probably be used, consisting of a tubular conductor enclosing a concentric return wire. As an indication of the relative band widths required for telegraphy, telephony, and television, it is interesting to note that the frequency range of a million cycles that can be transmitted over a coaxial line is sufficient for either 2,880 telegraph channels, 240 telephone channels, or one television channel.

The author desires to express his appreciation of the information made available to him by the officials of the Bell Telephone Company of Canada, Canadian Pacific Railway Company's Telegraph, Canadian National Telegraphs, Canadian Marconi Company, British Columbia Telephone Company and Maritime Telegraph and Telephone Company, Limited, and to Mr. J. S. Cameron, Mr. W. I. Brebner and Mr. E. S. Kelsey of the Northern Electric Company, Limited for assistance in compiling the paper.


Type of Modern Locomotive built for the Canadian National Railways and operating on various sections of the system throughout Canada.

*Illustrations through the Courtesy of the*
Canadian Locomotive Company, Limited

# Railway Construction

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Fifty years ago in Canada, or in 1887, the year in which the Canadian Society of Civil Engineers was incorporated, the Canadian Railways had already attained a considerable development. During the previous year, the Canadian Pacific had completed its line from Montreal to Vancouver and had inaugurated a daily passenger train service between the Atlantic and Pacific coasts.

The best description of the condition of the Railways in Canada in 1887 is probably given by Collingwood Schreiber, one of the Charter Members of the Canadian Society of Civil Engineers, in his report accompanying Railway Statistics of Canada, 1887, in which he says:—

"The year under consideration has been marked by much enterprise and activity in construction, and by a prosperity quite without example to the lines in operation. Thirteen new lines appear in the tables submitted herewith. Others, under construction last year, are now wholly or partially in operation. Iron rails are fast disappearing. The equipment of railways has received notable additions and improvements. The increase of the traffic has been such as no former year can show amounting to nearly $5,500,000."

figures, (mileage placed in operation) down to the present time shows a close co-relation with the business activity of the period but with a lag of about four years as, of course, the construction usually took place several years before the line was placed in operation. The depressions of 1895, 1911, 1919 and 1929-33, show up very clearly in these figures and accentuate the intervening boom periods.

The completion of the National Transcontinental, Grand Trunk Pacific and Canadian Northern lines, during the war, rather over emphasizes the boom during that period as the lines were started during the previous boom. The considerable increase of mileage during 1935 is due to the Hudson Bay Railway being placed in operation, as previously this had been shown as under construction.

During the decade following 1887 the two large railway companies, the Canadian Pacific and the Grand Trunk, developed their systems and acquired a number of the smaller railroads in their territories. The Canadian Pacific had a monopoly of the western traffic and developed feeders in the east with a winter port at Saint John, N.B. The Grand Trunk developed its system in the east with a winter port at Portland, Me.

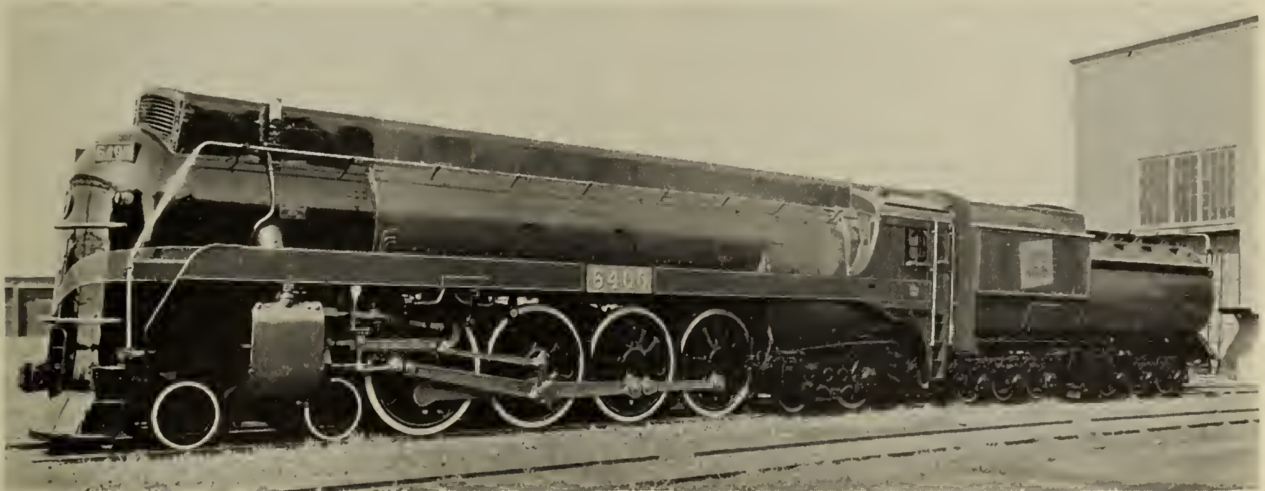

**Fig. 1—Canadian National Passenger Type Locomotive 6400, Built in 1936.**

In order to visualise the railway progress a schedule of railway construction and traffic in Canada has been prepared showing, for the period 1886 to 1936, the mileage placed in operation, the total mileage, the passengers carried and the freight carried. The maximum figure in each column has been underlined. These figures have been extracted from Statistics of Steam Railways of Canada published by the Dominion Bureau of Statistics and, as the final 1936 figures are not available yet, these have been estimated from figures for 1936 recently published by the Bureau of Statistics covering railways in Canada with annual operating revenues of $500,000 or over.

Very complete statistics covering the operations of steam railways are available during recent years and even in 1887 the statistics filled a standard blue book containing 56 pages. The figures selected are comparable over the whole period and show concisely the progress of railway transportation.

The large mileage (1,020) placed in operation during 1886 is due to the completion of the Canadian Pacific main line to Vancouver. Following this second column of

The prairies felt that the monopoly of the Canadian Pacific was not in their interests and the government of the province of Manitoba, which was the only organized provincial authority then in existence in the west, guaranteed the bonds of competing railroads to break the monopoly, finally getting a branch of the Northern Pacific into their province and also another outlet to the Great Lakes, the Canadian Northern to Port Arthur on Lake Superior, which latter line was completed in 1902. Even before this competitive outlet was available, the Dominion Government, in return for a subsidy of $3,360,000 to the Canadian Pacific for the construction of a line through the Crow's Nest Pass, had obtained a decided reduction of freight rates in the west by means of the famous Crow's Nest Pass Agreement which became effective January 1st, 1898.

During the second decade, the Canadian Pacific continued to make large profits and the Canadian Northern, although only in process of development, also showed large profits. The Grand Trunk system was very anxious to share in this western traffic, which was proving a veritable gold mine to the other companies, and in 1903 signed an agreement with the Government to construct a transcontinental railway from Prince Rupert to Moncton. The Grand Trunk undertook to construct the western section through a separate company, known as the Grand Trunk Pacific, from Winnipeg to Prince Rupert while the Dominion undertook to construct the Eastern section, known as the National Transcontinental Railway, and agreed to lease it to the Grand Trunk Pacific on its completion.

The close of the second decade found the Canadian Northern developing rapidly and both the Canadian Pacific and Canadian Northern making large profits in which the Grand Trunk was hurrying to share by building a complete transcontinental system as outlined in the previous paragraph.

The rapid growth of the Canadian Northern, in the prairie provinces, was made possible by these governments guaranteeing its bonds to a large extent and as this system developed it desired outlets of its own and endeavoured to obtain support for such developments.

In 1910 the British Columbia government guaranteed the Canadian Northern bonds for a line from Vancouver to the Alberta Boundary while the province of Ontario had in 1904 guaranteed the Company's bonds between Toronto and Sudbury. In 1911 the Dominion Government guaranteed the bonds for 1,050 miles of line east of Port Arthur, including the gap between Port Arthur and Sudbury, and made it possible to complete a third transcontinental system.

It is interesting to note that the route of the Grand Trunk Pacific Railway, through the continental divide, follows the earlier surveys for the location of the Canadian Pacific Railway, through the Yellowhead Pass, with the rails only 3,720.5 ft. above sea level, and provides the lowest pass for any railroad across the Rocky Mountains in the continent of North America. West of the Rocky Mountains the Grand Trunk Pacific diverges to Prince Rupert, but the Canadian Northern, built later, follows the old Canadian Pacific proposed location down the North Thompson river and provides a line with a maximum grade of five-tenths per cent westbound to Vancouver, and seven-tenths per cent eastbound, which ruling grades are much superior to those of the other lines through the British Columbia mountains.

The large mileage of railway construction, which was put in operation during the year 1912 to 1917, was made possible only by the assistance of the Dominion and provincial governments, as outlined above, during the period 1903 to 1911.

While the Grand Trunk and Canadian Northern were building up transcontinental systems the Canadian Pacific was expanding steadily by improving its main line and building an extensive branch line system.

In the year 1911, also, construction was started on the Hudson Bay Railway, surveys for which had been made in 1909; construction of this road was suspended in 1918 and not resumed till 1926.

The outset of the pre-war depression found the Grand Trunk Pacific and the Canadian Northern both with a large mileage of line under construction. Both these railroads got into financial difficulties and in 1914, all other sources having been exhausted, the Dominion Government stepped in and assisted both these companies to obtain funds to complete their lines under construction by guaranteeing their bonds.

The war came on and, even with a Government guarantee, it became impossible to obtain funds, so the Dominion made advances to the companies, taking whatever securities they could obtain, and enabled the Canadian Northern and Grand Trunk Pacific to complete their lines so that they could be placed in operation.

In 1915 the National Transcontinental and the Grand Trunk Pacific were completed, but the Grand Trunk, on the ground of excessive cost of construction, refused to take over the National Transcontinental, which was left on the Government's hands and subsequently operated as part of the Canadian Government Railway system.

In 1916 the Canadian Northern Transcontinental line was declared open for traffic and these new railways all found themselves in further financial difficulties.

The condition of the railways was so serious that, on July 13th, 1916, the Government appointed a Royal Commission to enquire into Railways and Transportation in Canada and this body, known as the Drayton-Ackworth Commission, made its report in April 1917. The majority report, signed by Sir Henry Drayton and Mr. W. M. Ackworth, recommended that the Government should take over the Canadian Northern, Grand Trunk and Grand Trunk Pacific properties, while the minority report, signed by Mr. A. H. Smith, recommended that the Canadian Northern properties in the east should be turned over to the Grand Trunk, that the Grand Trunk Pacific properties in the west should be turned over to the Canadian Northern and that the Dominion should operate or assist in the operation of the connecting lines between the east and the west.

The recommendations of the Drayton-Ackworth Report were adopted to the extent of the Government taking over the Canadian Northern on November 16th, 1917, while on March 10th, 1919, the Minister of Railways was appointed receiver for the Grand Trunk Pacific and on May 1st, 1920, under an agreement for acquisition, financial control of the Grand Trunk was taken over by the Dominion. At the same time as these large systems were being acquired by the Government nine short lines in the Maritimes were purchased and added to the Canadian Government Railway system.

The management of all the railways, controlled by the Dominion, was placed under the Canadian National Railway Company, which had been incorporated by Act of Parliament during 1919, and on January 1st, 1923, all these lines were consolidated for unified operation under this Company.

Large expenditures were, of course, required to consolidate this conglomeration of railroads into a reasonable system, but, in addition to this original problem, a large branch line development, particularly for the prairies, was entered into, resulting in the construction, by the Canadian National, of 1,895 miles of line between the years 1923 and 1931, while the Canadian Pacific entered into a similar branch line construction programme requiring the construction of 2,265 miles of line in the same period. In addition six short lines of railway in the Maritimes were taken over by the Canadian National and added to the system as branch lines.

During the post war boom period, 1923-1929, when these large branch line programmes were inaugurated, the railway freight transportation tonnage showed steady improvement and appeared to warrant the development, though passenger traffic was showing a slight decline due to the competition of the private motor car. However, when the severe decline in business set in, which reached its worst in 1933, it became evident that the railways were over developed, and on November 20th, 1931, the Government appointed a second Royal Commission to enquire into Railways and Transportation in Canada, known as the Duff Commission, under the Chairmanship of Sir Lyman Duff, Chief Justice of Canada. This Commission recommended a trustee form of management for the Canadian National Railways and also that machinery should be provided to enforce co-operation between the Canadian National Railways and Canadian Pacific Railway. These recommendations were duly accepted by the Canadian National-Canadian Pacific Act of 1933, but the sections of

Table I
Railway Construction and Traffic in Canada

| Year | Mileage placed in operation | Total railway mileage | Traffic carried | |
|---|---|---|---|---|
| | | | Passengers number | Freight revenue—tons |
| 1886 | 1,020 | 11,793 | 9,861,024 | 15,670,460 |
| 1887 | 391 | 12,184 | 10,698,638 | 16,356,335 |
| 1888 | − 21 | 12,163 | 11,416,791 | 17,172,759 |
| 1889 | 465 | 12,628 | 12,151,105 | 17,928,626 |
| 1890 | 523 | 13,151 | 12,821,262 | 20,787,469 |
| 1891 | 687 | 13,838 | 13,222,568 | 21,753,021 |
| 1892 | 726 | 14,564 | 13,533,414 | 22,189,923 |
| 1893 | 441 | 15,005 | 13,618,027 | 22,003,599 |
| 1894 | 622 | 15,627 | 14,462,498 | 20,721,116 |
| 1895 | 350 | 15,977 | 13,987,580 | 21,524,421 |
| 1896 | 293 | 16,270 | 14,810,407 | 24,266,825 |
| 1897 | 280 | 16,550 | 16,171,338 | 25,300,331 |
| 1898 | 320 | 16,870 | 18,444,049 | 28,785,003 |
| 1899 | 380 | 17,250 | 19,133,365 | 31,211,753 |
| 1900 | 407 | 17,657 | 21,500,175 | 35,946,183 |
| 1901 | 483 | 18,140 | 18,385,722 | 36,999,371 |
| 1902 | 574 | 18,714 | 20,679,974 | 42,376,527 |
| 1903 | 274 | 18,988 | 22,148,742 | 47,373,417 |
| 1904 | 443 | 19,431 | 23,640,765 | 48,097,519 |
| 1905 | 1,056 | 20,487 | 25,288,723 | 50,893,957 |
| 1906 | 936 | 21,423 | 27,989,782 | 57,966,713 |
| 1907 | 1,023 | 22,446 | 32,137,319 | 63,866,135 |
| 1908 | 520 | 22,966 | 34,044,992 | 63,071,167 |
| 1909 | 1,138 | 24,104 | 32,683,309 | 66,842,258 |
| 1910 | 627 | 24,731 | 35,894,575 | 74,482,866 |
| 1911 | 669 | 25,400 | 37,097,718 | 79,884,282 |
| 1912 | 1,440 | 26,840 | 41,124,181 | 89,444,331 |
| 1913 | 2,464 | 29,304 | 46,230,765 | 106,992,710 |
| 1914 | 1,491 | 30,795 | 46,702,280 | 106,393,989 |
| 1915 | *4,087* | 34,882 | 49,322,035 | 87,204,833 |
| 1916 | 2,103 | 36,985 | 43,503,459 | 109,659,088 |
| 1917 | 1,383 | 38,368 | 48,106,530 | 121,916,272 |
| 1918 | −116 | 38,252 | 44,948,638 | 127,543,687 |
| 1919 (June 30) | 78 | 38,330 | 43,754,194 | 116,699,572 |
| 1919 (Dec. 31) | 165 | 38,495 | 47,940,456 | 111,487,780 |
| 1920 | 310 | 38,805 | *51,318,422* | 127,429,154 |
| 1921 | 386 | 39,191 | 46,793,251 | 103,131,132 |
| 1922 | 167 | 39,358 | 44,383,620 | 108,530,518 |
| 1923 | 296 | 39,654 | 44,834,337 | 118,289,604 |
| 1924 | 405 | 40,059 | 42,921,809 | 106,429,355 |
| 1925 | 291 | 40,350 | 41,458,084 | 109,850,925 |
| 1926 | 0 | 40,350 | 42,686,166 | 122,476,822 |
| 1927 | 220 | 40,570 | 41,840,550 | 125,967,439 |
| 1928 | 452 | 41,022 | 40,592,792 | *141,230,026* |
| 1929 | 358 | 41,380 | 39,070,893 | 137,855,151 |
| 1930 | 666 | 42,046 | 34,698,767 | 115,229,511 |
| 1931 | 234 | 42,280 | 26,396,812 | 85,993,206 |
| 1932 | 129 | 42,409 | 21,099,582 | 67,722,105 |
| 1933 | − 73 | 42,336 | 19,172,193 | 63,634,893 |
| 1934 | − 66 | 42,270 | 20,530,718 | 75,746,093 |
| 1935 | 646 | *42,916* | 20,031,839 | 77,081,057 |
| 1936 | −208 | 42,708 | 20,455,000 | 84,677,400 |

Note: In 1919 the end of the statistical year was changed from June 30th to December 31st, the two sets of figures given for that year are both for twelve-month periods. Italics indicate *maximum* figure in each column.

the Act requiring enforced co-operation between the railroads have never been put in effect. An amendment to this Act was passed in 1936 revising the form of management of the Canadian National Railways and this new management took over on October 1st, 1936.

The financial condition of the railways has improved somewhat since the low of 1933 but it is still by no means rosy, particularly when compared with Collingwood Schreiber's description of 1887 conditions. During 1936 the Canadian National earned $6,408,911.26 available for interest but required contributions for deficits amounting to $43,303,393.82 from the Dominion and had, in addition, net charges during the year in its profit and loss account amounting to $12,684,818.25, while the Canadian Pacific paid its fixed charges amounting to $23,913,298.24, and transferred $6,029,183.92 to profit and loss, but the Company made various charges amounting to $7,001,168.68 against that account that making a net reduction of $971,984.76 in the profit and loss balance for the year.

It is apparent that the railways are equipped to handle much more traffic than they receive. This condition has been caused by various reasons, the principal ones being, over development of railway mileage, slowing up of development of the country, the existing depression of world trade, and diversion of traffic to competitive transport facilities both highway and waterway. An examination of the last two columns of Table I, Railway Construction and Traffic in Canada, shows that the passenger traffic reached a maximum in 1920 of 51,318,422 passengers but that, due principally to the diversion of this traffic to private motor cars, this had been reduced in 1936 to 20,455,000 passengers and it does not appear likely that any large portion of this loss can be regained. The freight traffic reached a maximum in 1928 of 141,230,026 tons and, owing chiefly to world conditions and partly to diversion of traffic to competitive transport facilities, this had been reduced in 1936 to 84,677,000 tons which, however, is a considerable improvement over the 1933 traffic of 63,634,893 tons.

The development of railway mileage compared with railway traffic is hardly a fair index of conditions, as the considerable improvement in grades and alignment, structures and locomotive equipment makes each mile of railway in 1937 able to handle many times the traffic of a mile of railway in 1887.

Statistics as to train loads are only available for thirty of the fifty years but these show that the average train load, which was 260 tons in 1907, had increased to 528 tons in 1935, while in 1928, due to the heavy wheat crop, an all time maximum average of 557 tons per train, was handled and during recent years there has been a steady increase in the average train loads as shown below.


**Fig. 2—Grand Trunk Passenger Type Locomotive 2196, Built in 1888.**

Average Tons per Freight Train

| | | | | | |
|---|---|---|---|---|---|
| 1927 | 514 | 1930 | 509 | 1933 | 521 |
| 1928 | 557 | 1931 | 514 | 1934 | 522 |
| 1929 | 523 | 1932 | 517 | 1935 | 528 |

The 1936 figures are not available yet for all railroads but for railroads with an operating revenue over $500,000 the 1936 average figure is 593.4 tons per train compared with 596.0 tons per train during 1935 or a slight decrease.

The principal reason for increased train loads is of course, improvements in motive power and some idea of these may be obtained from the two pictures of locomotives, which appear in this text—Grand Trunk locomotive No. 2196, built in 1888 and Canadian National locomotive No. 6400, built in 1936. This immense increase in the size of locomotives has, of necessity, required corresponding improvements in alignment, both grades and curvature, or possibly it might be better expressed by saying that improvements in alignment have made possible the increase in size of locomotives. In any case, the low grades and curvature on recently constructed railroads, as compared with those built fifty years ago, have increased the capacity of these lines for railway freight or passengers many times.

The high standard of construction and equipment in Canada has kept the freight rates at a low figure, amongst the lowest in the world, and this despite low traffic density, high wages, and the disadvantages of extreme climatic conditions.

This point of the low cost of railroad transportation in Canada is best set out by comparison with other countries and these figures are given for the year 1932 from the last issue of "Railway Statistics of the United States of America and recent statistics of Foreign Railways."

Receipts per Ton Mile (Cents)

| | | | |
|---|---|---|---|
| Canada | 0.94 | British India | 0.83 |
| United States | 1.052 | Mexico | 1.49 |
| Great Britain | 1.87 | Victoria | 2.15 |
| Germany | 1.49 | New South Wales | 1.92 |
| South Africa | 1.35 | South Australia | 2.33 |
| New Zealand | 3.41 | West Australia | 2.08 |

The only country among the above which shows a lower average freight rate than Canada is British India and, in that country, labour is so cheap and climatic conditions are so moderate that a low freight rate follows automatically.

Transportation in Canada has always been a serious problem, the small population being spread over a vast expanse of territory, so that geographical characteristics call for means of ready movement between the widely separated areas.

No country in the world, perhaps, is so dependent on transportation for the opening up of its undeveloped areas and the railways are and have been the greatest single agency in this respect.

With a further improvement in world conditions there is no doubt that there will be a corresponding improvement in the railway traffic available in Canada, but, even with this, it must be admitted that the railway mileage of Canada has been over developed and will require very careful administration and economical operation over a long period to preserve these assets for the benefit of the country as a whole, bearing in mind that the development of an extensive continental area like Canada is based entirely on the development of its railways.

# Road Building

*R. M. Smith, A.M.E.I.C.,*
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Fifty years, in most history, is a comparatively short space of time. But insofar as road building in Canada is concerned, it is almost impossible to describe a history of even fifty years. The last decades of the past century marked the era of railroad building on this continent and the construction of highways was at almost a complete standstill. As an illustration of conditions which existed one need only refer to the province of Ontario. In 1913 a commission was appointed to study the road needs of that province. Included in the report of this commission was a summary of the history of Ontario roads. The period from the seventeenth century to about 1850 was covered in a matter of some twenty pages, the following years up to 1913 occupied three paragraphs! Could anything describe more vividly the lack of interest in roads during this period?

In this brief review of road development in Canada during the past fifty years it is not proposed to go into technical developments, but to give a short description of the actual expansion of highway mileages and to the factors which led to that expansion. The technical features of the development have been covered minutely in the discussions of various bodies and need no elaboration here. But there is a certain romance in the building of roads, a romance which is evident in the parallel between the growth of the country and the growth and development of highways in Canada and these have coincided with the expansion of transportation.

A study of our road building cannot however begin in 1887. We must go farther back if we are to appreciate the circumstances which placed our roads where they are to-day. Some certainly would follow different routes were modern engineers turned loose this year to locate new highways most advantageously.

Water-borne transportation was the first important factor in the growth of Canada. The earliest roads were only feeders or auxiliary routes. The bulk of movement was by lake and river. It is difficult for the average citizen of Toronto in 1937 to realize, when he sees a constant stream of traffic flowing into and out of the city on Yonge street to points in Muskoka and farther north, that Yonge street was first laid out merely as a short cut between Lake Ontario and Lake Simcoe, in order to shorten the water passage to Georgian Bay. To-day it provides a means and an end in itself. Then it was only a short cut for faster movement of light goods.

Later roads were built for military purposes, to permit the movement of troops and supplies along a route more remote from possible southern invasion than was afforded by the waterways of the boundary.

Finally there were colonization roads, but as in the case of the earliest highways, their principal object was to provide access to the nearest waterway. They were seldom constructed as a primary means of transportation. They were still only feeders and connecting links.

In the middle of the nineteenth century the railroad began to supplant the waterway. And with the coming of the railway road building in Canada almost ceased. Waterways did not always reach the necessary areas and formerly some roads had been built of necessity. But the railroad, which could be taken to any point (and unfortunately sometimes was), provided better and faster transportation than horse-drawn vehicles and, in that era, could be financed much more easily than any road. For almost fifty years the only interest in roads that remained was confined to whether or not there was a passable road from a given point to the nearest railroad station.

Highway Views in the Province of Ontario

*First*—Highway No. 2, looking East towards Etobicoke Bridge, one of Ontario's four-lane highways.

*Second*—Oakville Bridge, looking North on Toronto-Hamilton Middle Road.

*Third*—Highway No. 2, East of Oakville, showing standard three-lane highway.

*Fourth*—Snow Plow clearing Ontario Highway following mid-winter storm.

*Illustrations through the Courtesy of the* Department of Highways of the Province of Ontario

During all this time there was practically no road improvement in any part of Canada, except in British Columbia where topographical conditions made the construction of railways extremely difficult and where pack trains were still the most practical means of transportation. In the period around 1870 some effort was made to construct a military road from Winnipeg to the Lake of the Woods, but this was abandoned when it was found that the last thirty miles were impassable. However, something was accomplished and the present highway route No. 12 of the province of Manitoba is located on a part of this early road.

Of course, similar sporadic and purely local undertakings of minor importance were carried out in many districts but there was no widespread demand for road construction. However, a little more than forty years ago there may be discerned the beginning of the good roads movement as we know it to-day. That beginning was the foundation of the Ontario Good Roads Association in the year 1894. The demand then was not for improved trunk highways as we build to-day, but for the improvement of local roads, feeders for railroads and contacts with market towns, the idea of a network of roads forming a complete and comprehensive transportation system not having at that time been envisioned. Nor could such a system be foreseen before the development of the motor vehicle made it practicable.

However, the year 1894 saw the awakening of the public mind to the value of good roads and the false economy of neglected highways which resulted in increased transportation costs. The vision was purely local but it was the seed that was to eventually produce the branches and trunk roads on which modern motor cars travel. This start was made in Ontario and it may be said without any suggestion of prejudice that the lead which was assumed in Ontario at that time has never been relinquished. In Ontario up to this time, and indeed for many years afterwards, road building continued to be a purely local responsibility, though provincial governments did contribute some financial assistance to the construction of some roads and assumed a large interest in bridge construction. Practically all work was done by statute labour and very frequently was productive of no lasting improvement.

About the year 1912, however, the motor car had been developed to a degree which, while giving no hint of the actual progress to be made, did give rise to a new demand for improved roads. It was not an entirely unopposed demand either. Farmers living along the more important roads protested that the fumes and dust from the operation of these vehicles would destroy their crops and ruin their land. Others, and in greater numbers, fortunately were able to see the advantages to be gained by convenient transportation, and supported the demand. In Ontario a Royal Commission was appointed to enquire into the whole situation, and the report of this commission, submitted in 1914, formed the basis for the establishment of the present King's Highway system, and led directly to the construction of the Toronto-Hamilton highway, the first paved rural road in Canada of any importance.

From that point roads have progressed along with the motor car. And it is perhaps only fair to say that the development of the motor car has been quite as important to road building as has the improvement in the science of road building. This is especially true in relation to motor trucks. Had adequate shock absorbers and springs as well as pneumatic tires not been developed for heavy vehicles, freight transportation by highway never could have been accomplished. Engineers could have built roads to carry these loads on solid tires but the cost of such highways would have been prohibitive. For the improvement in our highway systems a substantial share of credit must therefore be accorded to the automotive engineer.

The great diversity of problems and conditions makes consideration of the Dominion as a whole impossible excep under very general headings. The first of these is the contribution made by the Dominion government to road building. As mentioned before, until the second decade of this century road building, except for financial assistance given by the provinces was purely a local responsibility. About this time, however, the provinces began to assume direct or full responsibility for many of the most important roads, and under the Canada Highways Act of 1919 the Federal Government took over, in a very restricted measure, the job of fathering, financially, the most important projects. (The position might perhaps be better described as grandfather, instead of father.) Since that time the Dominion contribution to highway construction has mounted to a very large sum, particularly the contribution to Trans-Canada Highway construction, but the amount so contributed is in no way comparable, even yet, to the amounts spent by the provincial governments, and the heavy financial interest of the Dominion in railway ownership makes very doubtful the prospect of Federal road-building assistance ever reaching the proportions now contributed by provincial treasuries.

There is one very interesting feature revealed by the statistics covering the entire Dominion which should be mentioned before undertaking a brief review of regional progress. It is evident that, though road building was a neglected art in earlier days, road planning was not neglected. The first bulletin of the Dominion department with reference to roads contains a table showing a total road mileage of 447,384. In view of the fact that thousands of miles of highway have been constructed since then, it is amazing to find, in the 1935 report, that the total road mileage of Canada open to traffic in that year was 410,808. It must be that the earlier figures included thousands of miles of roads which had been laid out on plans but never opened.

More significant of progress, however, is the fact that in 1922 there was no effort made to classify roads by types of surface. Presumably paved roads were practically non-existent and the only designation of quality provided was the information that in the entire Dominion 8 per cent

**A Retread Road, Ontario.**

of the roads were described as "very fair to good." In 1935 approximately 25 per cent were shown as paved, gravelled, or otherwise surfaced.

### British Columbia

As pointed out previously, in earlier days road building in British Columbia suffered less from the progress of the railway than in any other province. The topography of the country was such that rail construction was difficult and expensive, beyond the ambition even of those daring pioneers who financed our other railroads. Trails were largely the order of the day. With the progress of road construction these same difficulties have been encountered. Magnificent roads have been built, but the linking up of a comprehensive highway system has been made almost impossible because of excessive costs, estimated in some areas to run as high as $500,000 per mile as compared with the twenty to forty thousand per mile average elsewhere. Despite these difficulties, however, there are over 13,000 miles of surfaced highways in this province.

### Alberta, Saskatchewan and Manitoba

The problems here are almost exactly the reverse of those confronting British Columbia. It is small population, long distances and lack of construction materials which handicap the engineers of the prairie provinces. Despite these obstacles, however, they have constructed long stretches of splendid roads. Because of the fact that these are largely agricultural provinces, it has been necessary to open a very great mileage and this has aggravated the difficulties because concentration on a few roads is impossible. The nature of the country has, of course, made possible the opening of roads at comparatively small expense, but the maintenance of this enormous mileage is a staggering undertaking. The result is that these three provinces enclose roads with a total length of more than 240,000 miles, or more than half in all the Dominion. But of these not quite ten thousand miles have been surfaced.

### Ontario

Ontario has been most fortunately placed in the matter of road building. Large quantities of construction materials are available; the nature of the country makes road building no more than ordinarily difficult; the population of the province, while scattered, is the largest in Canada, and consequently can afford to support a road system beyond the reach of other jurisdictions. With these facts in mind, there may reasonably be claimed for Ontario the position of premier province of this Dominion insofar as road construction is concerned. After making an early start, with an agitation for good roads commencing more than forty years ago, to-day the province has approximately half the total surfaced road mileage of Canada, and about half of all the motor vehicles in this Dominion. It may be added that the province's expenditures on road work total also about 50 per cent of the total Dominion expenditure. This is a position won by long and consistent work backed by sensible but heavy investment. At the present time more than two-thirds of Ontario's 70,000 miles of highways are surfaced, and nearly five thousand miles are paved.

Diversion of New Denver-Rosebery Road, British Columbia.

The province is now undertaking two very great tasks. The first is the paving of many of its northern roads, the second the construction of dual highways in the heavy traffic areas of the south. The first is necessitated by the growing importance of northern development and the failure of gravel roads to withstand the heavy traffic, and the latter by the phenomenal increase of traffic. Both will establish, even more firmly, Ontario's claim to leadership in highway work in Canada.

### Quebec

In this province there has arisen a problem of administration which has handicapped the splendid work done by the engineering departments. Some of Canada's finest highways have been built in Quebec but the absorption into the provincial system of some 18,000 miles of road, or practically half of the total in the province, has placed a financial burden on the provincial treasury which has limited the amount of new construction to be undertaken. Maintenance costs of this extensive system absorb such a large percentage of the total available as to make extensive new work impracticable. However, the highways already constructed and those under way are excellent examples of the finest road building technique.

### Maritime Provinces

Here again there exists a set of conditions differing entirely from those of other sections. The comparatively small area of these provinces makes extensive highway mileages, as we know them elsewhere, unnecessary. At the same time, comparatively small populations create the same problems as throughout the remainder of the Dominion. Except in Prince Edward Island, where the motor car has until recently been an almost negligible factor, a middle course has been chosen. The Maritime Provinces have a total of nearly 30,000 miles of highways, of which about 40 per cent is surfaced. In Prince Edward Island, however, only 16 miles of pavement and 195 miles of gravel highway had been constructed by the end of 1935.

There have been hundreds of outstanding personalities who have lent their assistance in the promotion of better highways in Canada who well deserve mention in an article of this kind. But to attempt such a list would be impossible in a brief review. In conclusion, however, there is one person to whom the author must make reference, since no record of Canadian road building would be complete without the name of A. W. Campbell, the first Canadian Commissioner of Highways and also the first Good Roads Commissioner of Ontario. As Dominion Commissioner of Highways, he was called upon to study conditions in the different provinces and in conference with the various provincial authorities his technical advice and experience proved invaluable. Shortly before his death, in the course of an address, he used the following sentence, which the author believes may well become the slogan of every highway engineer: "After a quarter of a century, a lifetime, I may say that I am still a student of roadbuilding and the man who to-day professes to know all about this question is making the greatest mistake that an engineer can possibly make." Those words were true a decade ago, and they are equally true to-day. Much has been learned, but in fifty years our highway problems have not been solved nor is it likely they will be ever entirely overcome. There has been progress, however, and if we remain students of roadbuilding, we shall see even greater progress during the next half century.

# Harbour Construction

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The importance of Canadian harbours to the general welfare of our Dominion is defined by Sir Alexander Gibb, in his National Ports Survey of 1931-1932, wherein he makes the following statement:

"The ports of Canada, although they have a capital value of about $370,000,000 only, are part of a transportation system which, including railways, canals and roads is assessed at $4,500,000,000 and constitutes over a seventh of the country's estimated wealth. The principal ports are not, as in many countries, founded on the service of a great exporting or consuming area in their immediate neighbourhood; nor have they been created and developed by merchant or shipping interests. They exist primarily as the connection between land and sea in the long route that the exports of Canada must take to reach their market; and for that reason, by the terms of Confederation, and in distinction from the position in the United States where the ports have remained almost entirely in the control of individual states and cities, almost all ports in Canada have become federal property."

There are six major seaports in Canada, namely Halifax, Saint John, Quebec, Montreal, Vancouver and New Westminster. Through these ports passes almost fifty per cent of the total foreign trade of our country and over seventy-five per cent of the overseas trade of Canada. There are a number of important harbours on the great lakes, of which Toronto, Port Arthur and Fort William are the principal. In the year 1929, the all time high in Canada's record of foreign trade, the total amounted to 2.65 billions of dollars, of which 1.26 billions passed through the six principal ports.

In dealing with the subject of this paper, the chief engineers of the principal harbours were consulted, and the articles which they kindly contributed are published herewith.

## CONSTRUCTION IN HALIFAX HARBOUR

The port of Halifax is located on the southeast coast of the province of Nova Scotia, in Latitude 44° 30′ north, Longitude 63° 45′ west. With relation to the ports of Europe and Africa it is nearer than any other North Atlantic port. The regular steamship lanes traversed by vessels plying between New York and Great Britain are about one hundred and sixty miles south of Halifax. It is, therefore, favourably situated as a port of call for passenger liners on this route.

The harbour is 7.5 nautical miles in from the open sea. Its entrance channel is from one-half to one mile in width, on a relatively straight course. The depth of water in the channel is from 50 to 110 ft. Including Bedford Basin, which forms an inner land locked harbour, the total area within the harbour limits, having a depth of 45 ft. or more, is about ten square miles. The tidal range at spring tides is 6.7 ft. and currents within the harbour at all stages of tide are negligible, the maximum rate at the Narrows leading to the Basin being less than one knot. Throughout the winter season the main harbour is free from ice.

During the winter season, when the St. Lawrence river ports are ice bound, the port of Halifax handles a large proportion of Canadian freight and passenger traffic.

The first extensive scheme of harbour development for Halifax was considered in 1911. It was proposed to construct four large reinforced concrete piers, with concrete pile substructures, at the deep water terminals. Only one of these piers was built, pier 2, which was begun in 1912 and completed early in 1915 by the Department of Railways and Canals. This pier is 780 ft. long by 235 ft. wide, carried on reinforced concrete piles, 24 in. square, in lengths from 55 ft. to 75 ft. The largest piles weighed about twenty-three tons. Thirty-three vertical and six inclined piles were driven in each bent, the spacing of the bents was 18 ft. between centres.

A two-storey reinforced concrete transit shed was erected on the pier. The building columns were spaced 39 ft. 6 in. transversely and 18 ft. longitudinally, the shed being approximately 680 ft. long and 200 ft. wide. Three piles were driven close together under each of the interior shed columns and two under each wall column, with one inclined pile at each column group. The main deck of the pier was constructed on the ordinary beam and girder system. The upper portions of the piles were cast after driving. They were capped with girders, 12 in. wide by 49 in., 38 in. and 36 in. deep, carrying beams 12 in. wide and 24 in. deep. The deck slab was 8 in. in depth. Two plies of 2 in. creosoted timber lagging, 8 ft. in height, enclosed the piles from low water level to 1½ ft. above high water. This was provided as a protection against erosion by frost action or other causes. The main shed columns in the lower storey were circular, 25 in. in diameter, and the wall rectangular, 16 in. by 20 in. The girders supporting the upper floor were 36 in. wide by 50 in. deep, carrying a 7 in. floor slab with 12 in. by 27 in. floor beams. The main columns of the upper storey were 12 in. square, the roof girders 12 in. by 42 in., carrying a 3½ in. concrete roof slab with 8 in. by 12 in. roof beams.

The live loads provided for in the design of this structure were: deck of first floor, 1,000 lb.; second floor, 500 lb.; and roof, 110 lb.

In 1930, after more than fifteen years of service, due to the severe frost conditions, the underside of the main deck structure had become damaged by spalling of the surfaces to such an extent that corrosion of the reinforcing steel had occurred. Repairs were effected by chipping off all loose concrete, sand blasting the steel and resurfacing all damaged sections with gunite concrete impregnated with finely ground iron. This work, which was done in 1930, is in good condition at the present time.

In September 1933 the upper storey of the transit shed was completely destroyed by fire but very little damage was done to the building below the upper floor level. The structure was stripped down to that level and the upper storey was reconstructed with a structural steel frame, corrugated iron siding, mill type wood roof covered with built-up tar and gravel roofing, and a complete sprinkler system was installed throughout the upper storey.

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E. L. Cousins, M.E.I.C., General Manager, Toronto Harbour Commissioners.
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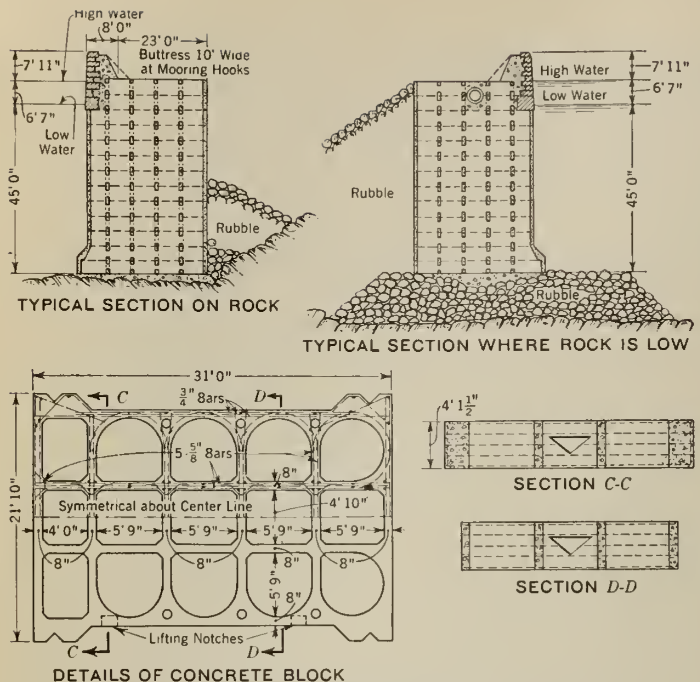


**Fig. 1—Detail of Dock Wall Construction, Ocean Terminals, Halifax.**

The deck of the pier at the north and south sides, and for a width of 24 ft. at the centre of the shed, is depressed 3 ft. 6 in. below the shed floor level. Four standard gauge railway tracks, two at the centre of the shed and one along each side of the pier, were provided. The deck level in way of the tracks is 15 ft. 8 in. above low water.

The depth of water at pier 2 is from 33 ft. to 57 ft.

### Ocean Terminals

Harbour development on a more extensive scale was undertaken in 1913 by the Department of Railways and Canals. This project took in a frontage of over 5,600 ft., the north end of which was about a mile south of the deep water terminals.

The scheme included the building of the connecting railway from Fairview, at the north end of the city, to the south end terminals; the construction of a classification yard along the shore of Bedford Basin, between Fairview and Rockingham; and the construction of docks, including 3,300 ft. of dock wall forming the Bulkhead passenger landing quay, and five piers, each 1,250 ft. long, having a mean width of 340 ft. The basins between piers were to have an average width of 340 ft. The draft to be provided at most of the berths was 45 ft. A breakwater, 1,400 ft. in length, at the south end of the frontage, completed the layout.

Contracts for the dock construction, carried out between 1913 and 1919, included the construction of the Bulkhead passenger landing quay, pier "A," the breakwater, and the two basins adjacent to pier "A." The total length of dock wall completed was 6,522 ft. The depth provided at the east face of the passenger landing quay, for a length of 2,006 ft., and at both sides of pier "A," was 45 ft. For the outer berth at the north side of basin 1, a depth of 35 ft. was provided, and 35 ft. for the inner berth.

The design adopted for the construction of the dock wall is shown in Fig. 1. It consisted of stacks of cellular concrete blocks, 31 ft. long, 21 ft. 10 in. wide and 4 ft. 1½ in. high, each block weighing about sixty tons. The blocks were reinforced to withstand the handling stresses and those which would exist after the dock wall had been completed and backfilled. A large area near the site was used for the casting and storing of the cellular blocks. The minimum thickness of the cell walls of these blocks was 8 in. They were kept in storage for at least three months before being placed in the work.

The harbour bottom at the site of this project consisted of ledge rock overlaid with harbour mud or a layer of clay and mud. The rock was encountered at or above elevation 45 ft. below low water throughout the greater part of the length of the wall, but at the outer end of pier "A" and midway along the front of the passenger landing quay the rock surface was quite a depth below that level. Except at these low places the procedure followed was to excavate the rock to grade and to place concrete pedestals to carry the corners of the blocks. These pedestals were placed by means of a large diving bell, especially constructed for the work, having a working chamber 34 ft. long, 26 ft. wide and 7 ft. high. This permitted accurate setting of the work and thorough inspection.*

Where the rock was only a few feet below the elevation of the bottom of the blocks, a mass concrete foundation was laid under water in a steel sheet-pile cofferdam. For depths beyond 55 ft. a rubble mound of quarry stone was placed and allowed to settle for a year before the concrete pedestals were set on it. This latter method was used for a length of about 600 ft. midway along the bulkhead passenger landing quay and for a length of 300 ft. at each side and across the front of pier "A."

The precast cellular blocks were placed on the prepared foundations by means of a large locomotive crane operated on tracks placed on the completed stacks of blocks. They were kept in vertical alignment by reinforced concrete guide piles placed in the triangular grooves formed in the sides of the blocks. After a stack of blocks, thirteen to a complete stack, was in place, all cells in the lower blocks were filled with concrete and those of the second were half filled. Circular holes extending through all blocks of a tier were then filled with grout, thus filling and bonding the horizontal joints between blocks. The front rows and middle transverse rows of pockets in each tier were then filled to the top with concrete, making a solid concrete buttress in each tier. The other pockets were completely filled with rock, gravel and sand. The two upper layers of blocks were made narrower than those below and set back from the face line. A mass concrete cope wall faced with granite was constructed from one foot below low water to the finished cope level 14.5 ft. above low water. A bank of rubble was placed at the rear of the wall to a height of 20 ft. below low water. Rock, earth and sand fill was used to complete the filling of the reclaimed areas. Work on the various contracts for dock construction was completed in 1919.

During 1917 and 1918 four single storey timber transit sheds were built at the Ocean Terminals, sheds 23 and 24 at berths at the north side of basin 1 and sheds 25 and 28 at the inner berths at north and south sides of pier "A."

Work on the erection of sheds 21 and 22 on the landing quay was begun in 1921. These sheds form one continuous building, 1,262 ft. long and 95 ft. wide. They are of two storey steel frame construction, 40 ft. high from floor to eaves on the west or track side and 54 ft. high on the east or harbour side. The foundations are concrete walls and pedestals on concrete piles, floors of reinforced concrete—the lower floor being surfaced with asphalt mastic. The roof is of mill type timber construction with five ply built-up roofing. The walls of the sheds proper are covered with asbestos protected metal, except at each end and at the central bay section, 100 ft. long, where the walls are of brick. Brick fire walls were constructed midway in each

*A complete description of this piece of equipment was published in The Engineering Journal dated October, 1918, pp. 252-262.

shed. The transit sheds are fitted with continuous sliding doors at each side on the lower floor and on the upper floor of shed 22 on the harbour side. Construction work on these sheds was suspended from 1923-1925 and the work was not completed until 1926.

The landing quay and general arrangement of the various buildings are shown in Fig. 2.

In 1929 two other transit sheds and an office building were built by the Halifax Harbour Commissioners; shed 20 and the Administration Building were constructed north from shed 21, and shed 27 at the outer berth on the south side of pier "A."

The Administration Building, three storeys in height, is of reinforced concrete and tile construction, faced with brick; the concrete foundation walls and pedestals are carried on timber piles driven into the fill. The building is 100 ft. by 66 ft., located at the north end of shed 20 and 60 ft. from the north end of the landing quay.

Transit shed 20, adjoining the Administration Building, extends northward along the landing quay for a length of 596 ft. to the north end of shed 21. Its width is 95 ft., with single span roof trusses. It is of steel frame construction carried on concrete foundations and timber piling. The floor is of concrete, surfaced with asphalt mastic. The height from floor level to eaves is 27 ft. The roof is of timber construction with five-ply tar and gravel roofing. The walls are of corrugated sheet steel fitted with continuous sliding timber doors on the east and west sides.

Transit shed 27 is a single storey building with structural steel wall columns, on concrete foundations. A Lamella type roof of segmental timber construction was erected. Two and three-eighth inch diameter tie rods extend across the width of the building, connecting the wall columns at the top. The timber roof is covered with five-ply built-up roofing. The main shed is 655 ft. long by 90 ft. wide. The floor is of concrete, surfaced with mastic. Along the north side main shed, for its full length, a track shed, 42 ft. wide, was constructed of structural steel frame with corrugated sheet steel siding, timber roof and tar and gravel roofing.

### Construction of Pier "B"

Further development of the ocean terminals was carried out by the Halifax Harbour Commissioners in the construction of pier "B" located about one thousand feet south of pier "A." The contract for this unit was awarded in January 1930 and work was finally completed early in 1933.

This pier, of the solid wall type, is 1,250 ft. long by 300 ft. wide. The cellular concrete-crib type of dock wall construction was used on this project.

The outer berths at this pier, for a length of 700 ft. on the south side and 900 ft. on the north, have a depth of

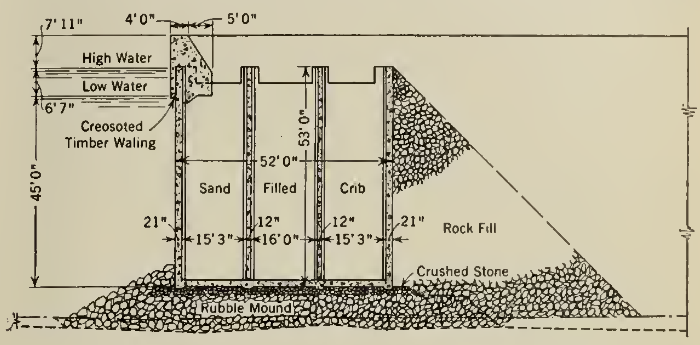


**Fig. 3—Section of Dock Wall, Pier B, Halifax.**

45 ft.; the inner berth sections have 35 ft. The adjacent basins at each side were excavated to these depths; that on the north side is 225 ft. wide and on the south side 255 ft.

Thirty concrete cribs were constructed for the dock wall; sixteen of the cribs were 107 ft. 3 in. long, 52 ft. 0 in. wide and 53 ft. 0 in. high; eleven of them were 107 ft. 3 in. long, 43 ft. 0 in. wide and 42 ft. 0 in. high. Three other cribs, approximately 75 ft. long, were placed, two of the larger section and one of the smaller. The cribs were constructed with concrete bottoms, the bottom slab being 18 in. thick, the outer side walls 21 in., the end walls 18 in. thick and the intermediate cell walls 12 in. thick. The interior cell walls were stopped off four feet below the side walls. Each crib was constructed to a height of about fifteen feet in a large timber pontoon. The bottom slab and the first lift of the walls were poured in fixed forms; sliding forms lined with sheet steel were then erected and the walls poured to a height of fifteen feet.

The pontoon had sufficient buoyancy to allow the crib to be built to that height, at which stage the crib would

**Fig. 2—*Majestic* at Ocean Terminals Wharf, Halifax.**

float with a freeboard of about two feet. It was then possible to remove the pontoon by sinking below the crib bottom. The crib was then moved to another berth and the concreting operations continued with the crib afloat, until the final height was reached. The pontoon on being re-floated was made ready for the next crib.

Ciment Fondu, a rapid setting, high early strength cement, was used in the construction of all of the pier "B" cribs. This cement was purchased in England and supplied to the contractors by the Harbour Commissioners.

In preparing the crib sites the overburden was removed and where the rock surface was above the required elevation it was excavated to two feet below the grade of the bottom of the crib. A course of crushed stone was laid to a depth of two feet and carefully levelled off to receive the crib. At the east end of the pier the rock surface was from 20 to 25 ft. below the grade required for the cushion course, and for a distance of 500 ft. on the north side and 700 ft. on the south side from the outer end the rock surface was below that elevation. Over these areas a rubble mound of quarry stone was placed and allowed to settle before the cushion course of crushed stone was laid. The top of the rubble mound extended out from the line of the cribs at least 17 ft. at the sides and 23 ft. at the outer end of the pier, and the crushed stone cushion was placed to at least five feet beyond the inner and outer lines of the cribs. Crib setting followed immediately after the work of preparing the foundations. (See Fig. 3.)

The cribs were towed into position and flooded by means of siphons. After setting in proper alignment, the cribs were completely filled with sand. The openings between cribs were closed with bagged concrete for a width of eight feet at the front and backfilled with broken stone. The line of cribs thus placed and filled with sand formed a solid wall enclosing the main fill.

All rock and other satisfactory fill material obtained from dredging was deposited within the pier area. Additional rock and earth was obtained from the excavation of the trackage areas immediately west of the pier.

To get proper alignment for the cope wall, it was necessary to construct a curtain wall of reinforced concrete along the face of the cribs from low water to the top of the cribs. A creosoted timber waling was bolted along the face at low water and hook bolts were placed through the wall above the waling to anchor the slab. This varied in thickness from 8 in. to 30 in.

Above the cribs and on the line of the curtain wall, a cope wall of Portland cement concrete was constructed to the finished height of the pier, 14 ft. 6 in. above low water. The filling of the pier was then completed to cope level.

Construction of the transit sheds on pier "B" was begun in April 1934 and completed in December of that year.

Two single storey sheds were erected, each 1,200 ft. long by 94 ft. 6 in. wide, with a connecting shed at the east end, 73 ft. by 80 ft.

The centre line of columns along the dock side was set 19 ft. 2 in. back from the cope line. The concrete pedestals supporting the front columns along the dock side of each shed were either carried on the intermediate walls of the cribs or on creosoted piling driven into the crib fill. At the inner or track sides of the sheds the concrete foundation wall and column footings were carried on spread footings where rock fill was encountered and on creosoted piling in on all other cases.

The shed frame was constructed of structural steel, with single span roof trusses. Corrugated sheet steel siding, steel sash and steel doors were used in the construction of the transit shed walls. Sectional vertical lift doors were provided in alternate bays on the quay side, and single section vertical lift doors in practically every bay along the inner or track sides. All doors are raised and lowered by means of mechanical devices, hand chain operated. The roofs were constructed of timber on steel purlins, covered with five-ply tar and gravel roofing. Concrete slabs were poured over the entire floor area and also between the cope wall and the sheds.

At the west end of each shed a two storey reinforced concrete and brick building was erected, 96 ft. by 22 ft., to provide office accommodation and special storage rooms.

The buildings are completely equipped with an automatic sprinkler system and twenty-six 2½ in. standpipes for fire protection. A brick fire wall was constructed midway in each shed, subdividing each into two 600-ft. sections.

During 1935 two other projects of dock construction were built, a 730-ft. extension to pier 9 at Richmond terminals, and a small pier at the cold storage terminal to serve as a fish pier, 290 ft. wide and 200 ft. long, with bulkhead sections adjacent thereto.

The type of construction used at the fish pier was similar to that used for pier "B," but on a smaller scale. In this case the main cribs were 70 ft. long, 30 ft. wide and 29 ft. high. The outer walls of these cribs were 18 in. thick, intermediate walls 12 in. and the bottom slab 12 in. Portland cement concrete was used in the cribs and cope wall of this pier. Quarry rubble mounds and crushed stone cushions were used in the same manner as for pier "B." The cribs were constructed on the beach, just above high water, on sliding launchways, to a height of 15 ft., and launched from seven to ten days after being built to this height. The remaining sections of the walls were poured with the crib afloat. Gravel filling was used in the cribs after setting. The cope wall was constructed to fourteen feet six inches above low water, corresponding to the cope level throughout the ocean terminals.

The extension to pier 9 at Richmond terminals was constructed of rock filled close-faced timber cribs up to a height of 1 ft. 8 in. above low water and a mass concrete cope wall was built thereon to a height of 14 ft. 6 in. above low water. The depth of water at this berth is 30 ft. There were eight timber cribs constructed for the work, six of them being 101 ft. 8 in. long, 35 ft. wide at the bottom and 31 ft. 8 in. high at the face and stepped at the rear. Creosoted Douglas fir was used for the face timbering and all cross ties entering the face. Untreated hemlock and spruce timber were used throughout the interior and rear of the cribs.

The original harbour bottom at the side consisted of ledge rock overlaid with from two to six feet of mud and clay. The over-burden was excavated from the crib sites and where the rock surface was higher than 31 ft. below low water it was excavated to 31 ft. 6 in. Low places were filled with quarry rubble and the entire area brought to the grade of the crib bottom by placing about eighteen inches of crushed stone cushion. After the cushion course had been carefully levelled off the cribs were sunk in place and completely filled with stone. The concrete cope wall was then constructed.

The reclaimed area at the rear of the wall was filled with the rock and other material from dredging and with earth and gravel deposited from dump trucks.

Other facilities provided at the port of Halifax are the grain elevator and cold storage plant, located at the ocean terminals. The cold storage plant has a million cubic feet of refrigerated storage space for the handling of fish, meats, fruit, vegetables and other food products. The refrigeration plant has an equivalent capacity of over five hundred tons per day. The grain elevator has a storage capacity of 2,200,000 bushels. Conveyor galleries to five berths were provided for delivery of grain to vessels, and one marine leg at berth 25, for unloading grain from vessels, has a capacity of 12,000 to 15,000 bushels per hour.

Of the privately owned piers constructed within the harbour limits, three are of special interest.

The Furness-Withy pier, located a short distance south of deep water terminals, was built in 1917. This pier is 580 ft. long by 90 ft. wide, constructed on concrete cylinders 6 ft. and 7 ft. in diameter. Four cylinders were placed in each bent braced with horizontal and diagonal struts of reinforced concrete. Longitudinal and transverse girders support the reinforced concrete deck. A single storey warehouse, 514 ft. long by 69 ft. wide, of reinforced concrete construction, was erected on this pier.

Immediately south of the Dartmouth ferry landing on the Halifax side of the harbour, a creosoted pile wharf was constructed in 1928 by the Western Union Telegraph Company. It is 360 ft. long by 54 ft. wide. All timber used in this work was creosoted. The deck slab was constructed of reinforced concrete and a timber shed, 280 ft. by 30 ft., erected thereon.

In 1935 the Imperial Oil Company constructed a dock at Imperoyal on the east side of the harbour. This pier has a creosoted pile trestle approach 315 ft. long extending from the shore to the pier head. Four large cribs of Portland cement concrete, 98 ft. long, 44 ft. wide and 44 ft. high, were constructed to form the pier head; sliding forms were used for the construction of these. The cribs were set on a rubble mound, with a crushed stone cushion course. The cribs were completely filled with gravel and sand after placing. A concrete cope was constructed on all four sides and a concrete pipe duct was provided at rear of the dock, and the remainder of the area filled to cope level and covered with a concrete slab. Vertical and horizontal fender timbers were provided along the west side of the pier.

The administration of the port of Halifax is now under the National Harbours Board, Ottawa.

## RECENT CONSTRUCTION IN SAINT JOHN HARBOUR, N.B.

The great tidal range in Saint John Harbour, 28 ft. at spring tides, necessitates the construction of much higher wharf structures than are ordinarily required in harbour development. To provide a berth having 30 ft. depth at low water, with provision for deepening to 35 ft., it is necessary to construct wharf walls at least 67 ft. in height. This, taken in conjunction with the fact that river silt is deposited in considerable depths over a large part of the harbour, greatly complicates the problem of providing structures with the necessary stability, at a reasonable cost.

Two major wharf developments of some considerable interest have been undertaken in this harbour during the past eight years, namely, the Navy Island development, and the reconstruction of berths 1, 2, 3 and 4. Although the structures are founded on rock in both developments, in the former case the rock surface varied from slightly below the berth grade to about coping level, while in the latter case, it varies from slightly below the berth grade to 46 ft. below that level.

### Navy Island Development

The Navy Island development consists of a two-berth pier, 700 ft. in length, and a quay wall 857 ft. 6 in. long, connected by a 300-ft. bulkhead wall. The slip between the pier and quay wall is 300 ft. wide at the bulkhead line, and 360 ft. at the outer end of the pier. Another 300-ft. bulkhead wall forms the head of the slip on the opposite side of the pier. Berth grade level is elevation −35.

On account of the large quantity of submarine rock to be removed, it was decided for economic reasons to carry out the work within a cofferdam, which enclosed an area of 43 acres. This, in addition to greatly reducing the cost of the rock excavation, made it possible to design a much more economical wharf structure. (See Fig. 4.)

In designing the structure, advantage was taken of the fact that the rock surface extended above the berth grade over nearly the whole area. The type of structure adopted also reduced to a minimum the quantity of rock excavation necessary to provide for its foundation.

The lower half of the structure consists of concrete buttresses, 5 ft. wide, spaced at 25-ft. centres. The buttresses are built against the rock slope and support a reinforced concrete arched slab, the rise in the arch being 4 ft. and the crown thickness 2 ft. A cut-off wall is built in with the slab along its back edge and extends down to the spring line. On top of the slab, a mass concrete retaining wall extends up to coping level. The fill immediately behind the structure is rock.

On account of the variation in rock elevation, three widths of structure were established, namely, widths of 28, 32 and 36 ft., and two levels were established for the spring line of the arch, namely, elevations 0.0 and −5.0. The upper level was established in order to reduce rock excavation when the rock surface extended above elevation −5.0. The 28-ft. wide section was used on both levels in order to extend this economical section as far as possible. Where the rock surface was below elevation −5.0, the spring line was carried at this level for both the 32-ft. and 36-ft. widths. Where the rock surface extended so low that the backfill would spill over the top of the excavated rock slope, a retaining wall was constructed between the buttresses, at their base, to prevent the fill from extending out into the slip. Expansion joints were made in the slab and retaining wall over the centres of alternate buttresses. It was found, however, during construction that the top six feet of the retaining wall tended to crack about half way between these joints. In order as far as possible

**Fig. 4—Navy Island Development, Saint John, N.B., before Removal of Cofferdam.**

to prevent these cracks, an additional expansion joint was made in the top section.

The transit sheds are single storey, and are ninety-five feet wide, over all. The frames are structural steel, and the roof trusses span the full width of the shed. The siding is galvanized corrugated steel and the roof is wood three inches thick, covered with a five-ply built-up asphalt and gravel roofing. The shipping doors are of steel and slide horizontally, and are continuous on both back and front of the shed. The floors are concrete. Grain shipping galleries are carried above each shed. The work was completed and in service early in 1932.

Reconstruction of Berths 1, 2, 3 and 4

Berths 1, 2, 3 and 4 were among those destroyed by fire in June 1931. Berths 2, 3 and 4 form one side of Saint Point slip, and berth 1 parallels the harbour channel. Berth 1 is 769 ft. 4 in. long, berths 2 and 3 combined are 753 ft. 4 in. long, and berth 4 is 600 ft. long, the total length of wharfage being 2,122 ft. 8 in. The bulkhead wall between berths 4 and 5 is 324 ft. long. The berth grade level is elevation -35 for berth 1, and elevation −30 for berths 2, 3 and 4.

The depth at which rock was found varied considerably and very irregularly. The highest was at elevation −35, and the lowest at elevation −83.4. The class of material overlying the rock is also variable. In berth 4, and part of berth 3, a six-foot layer of very hard clay, mixed with sand and gravel, lies in contact with the rock, and over this is a deposit of stiff red clay, sloping off from about low water level at the inshore end, to disappear at the outer end of berth 4. Very little hard material was encountered in the other berths, most of the overlying material being silt of various degrees of compactness. A considerable number of boulders were encountered at the inshore end of berth 4 and throughout the length of berth 2. Most of these were removed without blasting.

During the preliminary investigation, various types of construction were studied. The great depth to which the soft material extended over a large part of the site eliminated the more ordinary types, and it was finally decided that some form of construction in which cylinders were sunk to a solid foundation would be the most suitable. Various combinations of cylinders, and cylinders with piles, were considered, the type adopted being found to most nearly combine conditions of satisfactory foundation with reasonable economy.

The structure is made up of a series of transverse bents supporting a reinforced concrete slab and is shown in cross-section in Fig. 5. The bents are spaced 20 ft. apart longitudinally, each bent consisting of two concrete cylinders, spaced at 25-ft. centres, supporting a transverse wall, and two timber pile clusters of 13 piles each, at 24-ft. centres, supporting concrete columns. The units are tied together transversely by concrete struts, and longitudinally by continuous front and rear walls, and by concrete struts. The rear wall is supported on timber piles. The tops of cylinders and pile clusters, and the base of the rear wall are at elevation 15, which is about half tide level. The deck slab is supported on the walls and columns. This slab, excepting the part supported by the transverse walls over the cylinders, is designed as a two-way flat slab. The only girders are two transverse girders at each expansion joint, and one continuous longitudinal girder over the inner row of cylinders. The columns have a circular section. The reason for adopting the flat slab, and making the columns round instead of square, was to eliminate as many sharp corners as possible, these being considered the most likely points of attack by sea water and frost. Expansion joints are 120 ft. apart.*

During the pile driving operations at berth 4, serious ground disturbance took place, resulting in some outward movement of the slopes. After careful investigation it was decided, in order to reduce the horizontal thrust on the slope and structure, to build a 50-ft. wide relieving platform at the rear. This platform is at elevation 15 and consists of a timber deck supported on timber piles.

The cylinders are precast reinforced concrete shells, 12 in. thick and 9 ft. in diameter. They were cast on end in the dry dock in lengths of from 55 ft. to 70 ft., a steel cutting edge being fixed in the base of each. The cylinders were sunk by the open dredging method, kentledge being applied when necessary, after which they were filled with concrete. The very fine floating equipment provided by the contractor greatly facilitated the sinking of the cylinders. This was the most hazardous part of the work, but it has been completed without encountering any serious difficulties. It is expected that the construction of these substructures will be completed during the summer of 1937.

The great tidal range in this harbour exposes large surfaces of the structures to severe frost action as well as to the action of sea water. To resist disintegration of the concrete, its surface must be as nearly watertight as possible. In both the developments described above, great care was used in the control of concrete operations, both as to proportioning the materials and the mixing and placing. At Navy island, the cement content is 564 lb. per cubic

*For a fuller description of this work, see The Engineering Journal, October, 1936, pp. 437-445.

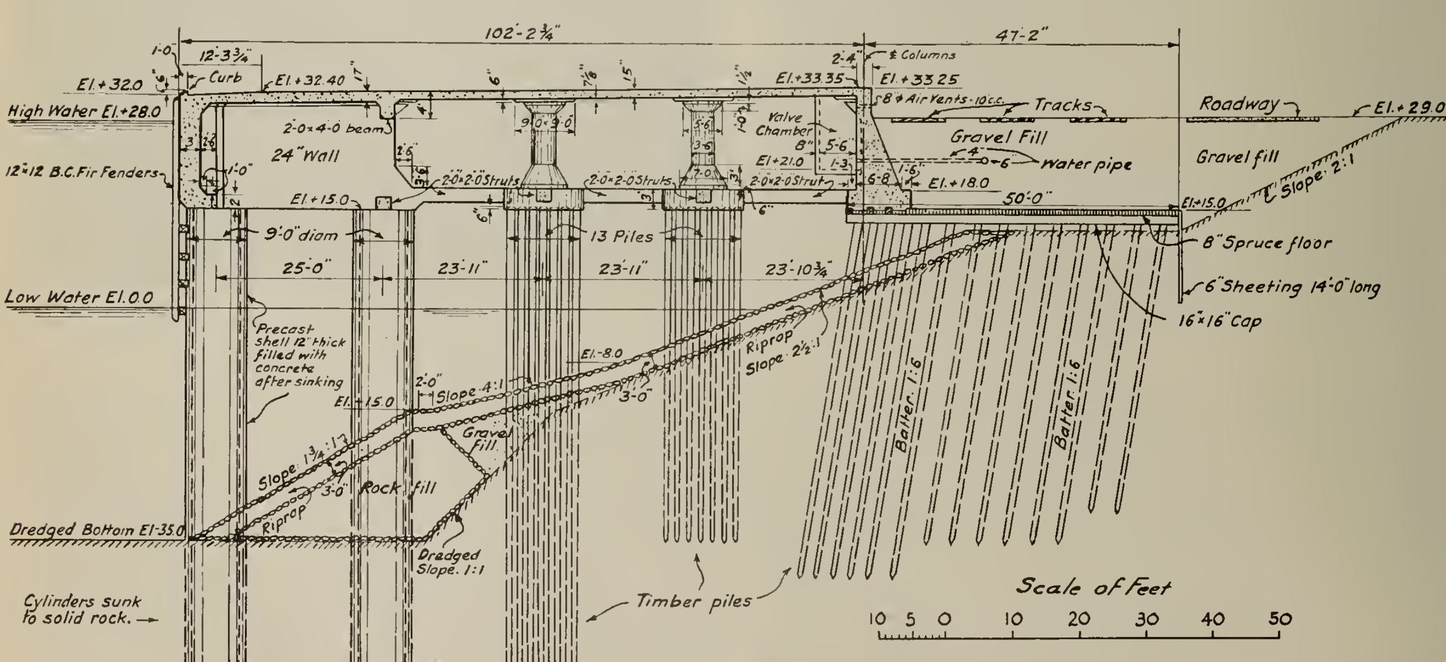


Fig. 5—Section Berths 1, 2, 3 and 4, Saint John, N.B.

yard, except an 18-in. facing within the tidal range, which is 658 lb. At berths 1-2-3-4, the cement content is 658 lb. in all concrete except the cylinder fill, which is 470 lb. The Navy island wharves have now been in service for three years and practically no evidence of disintegration can be found.

### THE PORT OF QUEBEC

The first real development of the port of Quebec began a few years before the appointment of the Quebec Harbour Commissioners in 1876. The general plan comprised practically all the wharves of that time, and also considerable enlargements in the estuary of the River St. Charles. The embankment wall forming the north wall of the inner and outer basins of the Princess Louise docks was completed in 1882, and the cross-wall dividing the two basins in 1886.

Pier 1 is of later construction, having been completed in 1907; and the St. Charles river wharf, a northern extension of the Princess Louise embankment, was built in 1917, and completed at the west end by an extension in 1930.

The latest development of the harbour has been at Wolfe's Cove terminals, where a modern ocean terminal was completed in 1931, for the 42,500-ton *Empress of Britain* and other transatlantic liners.

**Fig. 6—Princess Louise Basin, Quebec.**

#### Quay Wall Construction

In the development of Quebec harbour during the past fifty years, as briefly outlined above, the timber crib gravity has been, with few exceptions, the preferred type of quay wall, as this type of construction has been found most suitable for the local conditions. Of late years the superstructure of the quay walls from low water to coping level has been made of concrete to obviate the necessity of the renewal of face timbers exposed to the air.

Up to twenty years ago the maximum depth of water required at the wharves in Quebec harbour was from 25 to 30 ft. at low tide, but the increasing draft of ocean vessels necessitated providing greater depths at ocean berths and the quay wall at the new Wolfe's Cove terminals was designed to provide a maximum of 40 ft. of water at low tide. This greater depth has considerably increased the cost of gravity quay walls, as with the spring tide range of over 22 ft. at Quebec, the timber cribs with concrete superstructure have a total height of 70 ft., and the width of the timber crib at the base is 60 ft.

The timber used in the construction of the cribs is 12 in. by 12 in. dressed on two sides. Southern pine was used in the St. Charles river quay extensions in 1917-1918, and B.C. fir at the Wolfe's Cove development and in the St. Charles west end extension in 1930.

These gravity timber quay walls are designed to resist overturning, for the bearing capacity of the ground, and to resist sliding. In the most recent designs a surcharge of 1,000 lb. per sq. ft. was provided for. As an added factor of safety against sliding in the quay wall built in the St. Charles river in 1929, anchor piles were driven through the front pockets to a depth of 20 ft. into the crib seat, and pockets were also left open to permit the stone filling to penetrate into the ground.

An exception to the gravity type of quay wall exists at the western extremity of the St. Charles river quay wall, where a steel sheet piling bulkhead wall was erected in 1929. At that location it was imperative that the quay wall should be of impervious construction, and no sliding movement could be tolerated, as the bulkhead formed a protection wall for a marine railway slip.

This steel bulkhead wall, as far as the author is aware, was the first of this type built in this country. The steel sheet piles were driven 15 ft. below the ground elevation, and the lower tie-rod was placed two feet above mean low water, giving a span of 32 ft. Carbon steel of high tensile strength was used to obtain the necessary section modulus without excessive weight. Structural steel was used for all other steel members. The anchor wall was of reinforced concrete on wooden piles, while a concrete coping was placed on the steel sheet piling to complete the wall.*

#### Masonry Walls

Masonry walls were extensively used some fifty years ago, and proved satisfactory and economical for the quay requirements of that time. An example of this type of construction is the cross-wall forming the division between the inner and outer basins, and enclosing the entrance gates to the inner basin at its southern extremity. This masonry wall was built in 1886 and apart from the addition of a few tie-rods has required practically no maintenance; its present condition would indicate a further useful life of another fifty years.

#### Inner Basin Entrance

In 1886 work was started on the entrance gates to the inner basin, as well as the installation of sluice valves between the inner and outer basins. These entrance gates are of timber and are in duplicate. They are operated at high tide to allow navigation between the inner basin or wet dock and the outer basin or tidal harbour, the vessels berthed in the inner basin being kept at the same level with the coping of the wharf, regardless of the stage of the tide.

These wooden gates have been in continuous service since their installation some fifty years ago, and the machinery for the operation of the sluice valves, installed at the same time, has been operated daily during the navigation season over the same period, with only minor repairs.

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*For details, see the author's paper in The Engineering Journal, July, 1931, pp. 394-397.

Courtesy of Royal Canadian Air Force.

Fig. 7—*Empress of Britain* at Wolfe's Cove, Quebec.

The draw-bridge over the entrance gates to the inner basin was completed in 1888, and is also still in service. However, the ever increasing auto-truck loads will necessitate its replacement by a heavier structure in the near future.

A single-track railway bascule bridge, having an 88-ft. span, was erected over the entrance to the inner basin in 1912. It has been in continuous service since its construction.

### Graving Docks

Another example of the utility of masonry walls is the Lorne graving dock at Lauzon (Levis) in Quebec harbour, on the south bank of the St. Lawrence river, which was built by the Harbour Commission in 1886, and has been in continuous service since that time. The travelling caisson provided for this dry dock was a decided improvement over the older type of dock gates, and was one of the features of the design of this dry dock at the time.

While the Lorne graving dock, with its 600-ft. length, was adequate at the time of its construction, the increasing length of ocean liners in the early part of the twentieth century necessitated the construction of the Champlain dry dock, on a site near the Lorne dock at Lauzon.

The Champlain dock was built by the Dominion Government under the supervision of the Department of Public Works. It has a total length of 1,150 ft. from the outer caisson to head wall, and a width of 120 ft., with a depth on sill at high water of 40 ft., being the largest dry dock in the world at the time of its construction in 1918.

It is divided into two compartments by a floating caisson, one compartment being 650 ft. and the other 500 ft. in length. It was constructed of concrete, with granite steps, altars and quoins. Its location in solid rock involved the removal of 342,000 cubic yards of rock.

The outer entrance is closed with a rolling caisson. The floating caisson for the inner entrance can also be used to close the outer entrance in case of emergency.

The dock is emptied by three centrifugal pumps, each with a capacity of 63,000 gal. per min., and about two hours is required to empty or fill it.

Fully equipped modern repair plants are provided at both the Lorne and Champlain dry docks.

### Wolfe's Cove Terminals

To accommodate the increasing tonnage of ocean liners, especially in the period following the Great War, and in order to permit the port of Quebec to retain its position as a modern seaport, it was deemed advisable to develop the harbour frontage west of Champlain Market. Here a protected section of the harbour, known as Wolfe's Cove, afforded ample space for extended development for deep draft vessels.

The location of these new developments was selected after an exhaustive study of all the sites in the harbour. Preliminary work commenced in 1924, and construction started in the fall of 1925, a contract having been let covering the necessary dredging and quay construction for the first section of this project. A launchway and trestle were built near the site of the work for the construction of the timber cribs.

The type of quay wall used for the first section of the Wolfe's Cove terminals was a timber gravity crib up to low water level, and a pre-cast concrete superstructure from low water to coping level at elevation 124.00. The main cribs were 202 ft. in length and 60 ft. in depth, with anchor cribs of 60 ft. front and 150 ft. in depth, placed every fourth crib. Each main crib required about 1,200,000 ft.b.m. of B.C. fir, the total amount of timber in the quay wall being 28,000,000 ft.b.m. Some 330,000 cu. yd. of one-man stone were used as fill These cribs were placed in a trench dredged to 45 ft. below low water.

The concrete superstructure is also of the gravity wall type, but was constructed in pre-cast reinforced concrete sections, the wall having been made by placing pre-cast I sections on top of the timber cribs and filling with mass concrete. The facing of the superstructure of the quay wall was made of pre-cast concrete blocks. Some 60,000 cu. yd. of concrete were used in the construction of this superstructure.

The necessary filling back of the quay wall was obtained from the dredged material removed in the crib seats and in the berth areas in front of the quay wall. Over 6,000,000 cu. yd. of blue clay, sand and gravel were dredged and placed for this filling.

A rip-rap embankment was constructed from the south end of the quay wall to meet the shore line near Wolfe's Cove, and provide a storage yard and place for transfer tracks at the southern approach to the terminals. Temporary wooden bulkheads were also provided at the northern and southern extremities of the quay wall to retain the fill.

In 1930 the foundations were laid for a modern two-deck passenger and freight landing shed, 1,380 ft. by 100 ft., with a railway terminal adjacent thereto. This shed was built on the newly constructed quay wall at Wolfe's Cove terminals, and was designed especially for the *Empress of Britain*, then under construction. Special precautions had to be taken in the design of the foundation of the shed to prevent any possible settlement or lateral movement. Wooden piles were driven into the old formation of the ground. A reinforced concrete foundation resting on the pile clusters was chosen as being most suitable to carry the dead load of the shed, and a live load of 450 lb. per sq. ft. for the lower deck and of 250 lb. per sq. ft. for the upper deck was provided for. This shed has now been in operation since 1931, with no appreciable settlement or lateral movement, notwithstanding that some 25,000 tons of newsprint paper have been stored in it during the past few winters.

The lower deck is for freight and the upper deck for passengers and light baggage, although heavy commodities are stored on the upper floor when necessary. Office accommodation and passenger waiting rooms are provided at the east end of the shed. Covered passageways connect directly with the adjoining railway terminal, allowing passengers to board and leave trains rapidly, with no inconvenience from the presence of freight or from the handling of baggage. Provision has been made to accommodate four passenger and one baggage train at one time, and the length of the shed allows two modern liners to berth and handle passengers and freight with dispatch.

The transit shed is provided with two baggage elevators of 5-ton capacity, three large stairways to serve passengers arriving or leaving by taxi or bus, four spiral stairways for longshoremen, and four baggage chutes. A driveway down the centre is sectioned off by the shed columns. The wearing surface of the upper and lower floors is 2-in. sheet asphalt, over a concrete floor.

The outshore wall of the first and second decks, and the inshore wall of the lower deck are fitted with continuous doors of the two-section turnover type. These doors are 18 ft. wide and 16 ft. high on the river side. On the track side the doors are 18 ft. wide and 12 ft. high, except for every fourth door which is 14 ft. high, in order to provide clearance necessary to handle large boxes, crates, etc. These doors are framed by structural steel shapes, diagonally braced, with riveted connections throughout, and covered with steel plates of No. 14 gauge. They were designed to withstand a wind pressure of 30 lb. per sq. ft. They are so counter-balanced as to operate freely and easily in all positions, with a maximum pull of 35 lb. The lower structural members of doors as well as cover plates are of copper-bearing steel.

A heavy-duty cargo beam, of 5-ton capacity, has been constructed the full length of the transit shed to permit placing gangways and handle cargo in conjunction with ship's tackle.

The dock front is provided with all required water and fuel oil outlets, of sufficient capacity to provide rapid servicing of vessels.

## WHARF CONSTRUCTION IN THE HARBOUR OF MONTREAL

Certain physical and especially climatic conditions at the harbour of Montreal were the principal reasons, several years ago, for the choice of the type of wharf structure now adopted there for a group of wharves in the vicinity of the Jacques-Cartier bridge.

The past decade's channel dredging operations have lowered the surface of the river water to such an extent as to render fordable the undredged portion of the stream. In other words, the flow of the river has been mostly diverted into the dredged channel, which is but a fraction of the two miles width of the river at that point. The result has been the acceleration of the current therein, which was already rapid due to the constriction of the river section by the presence of St. Helen's island in its centre.

On the other hand, the territory of the harbour of Montreal was so defined by an Act of Parliament that wharves, piers, rails and driveways had to be and were all reclaimed from the river.

The provision of wharves in the style of piers or slipways was therefore out of the question at that particular section of the harbour, because the establishment of piers in the river would have the objectionable result of greatly reducing the channel width and increasing the velocity of the stream. A narrow shore wharf was the only alternative and in the earlier part of this particular development, that type was adopted. It has many disadvantages however, as well be seen from Fig. 8, when the following points are noted.

With a group of shore wharves established in a straight line and with provision of say 500 ft. berths, the length of the ships berthing at the individual berths cannot exceed 500 ft., otherwise the adjoining ships would overlap. But, assuming that all the ships accommodated at this particular group of wharves are not longer than 500 ft.,

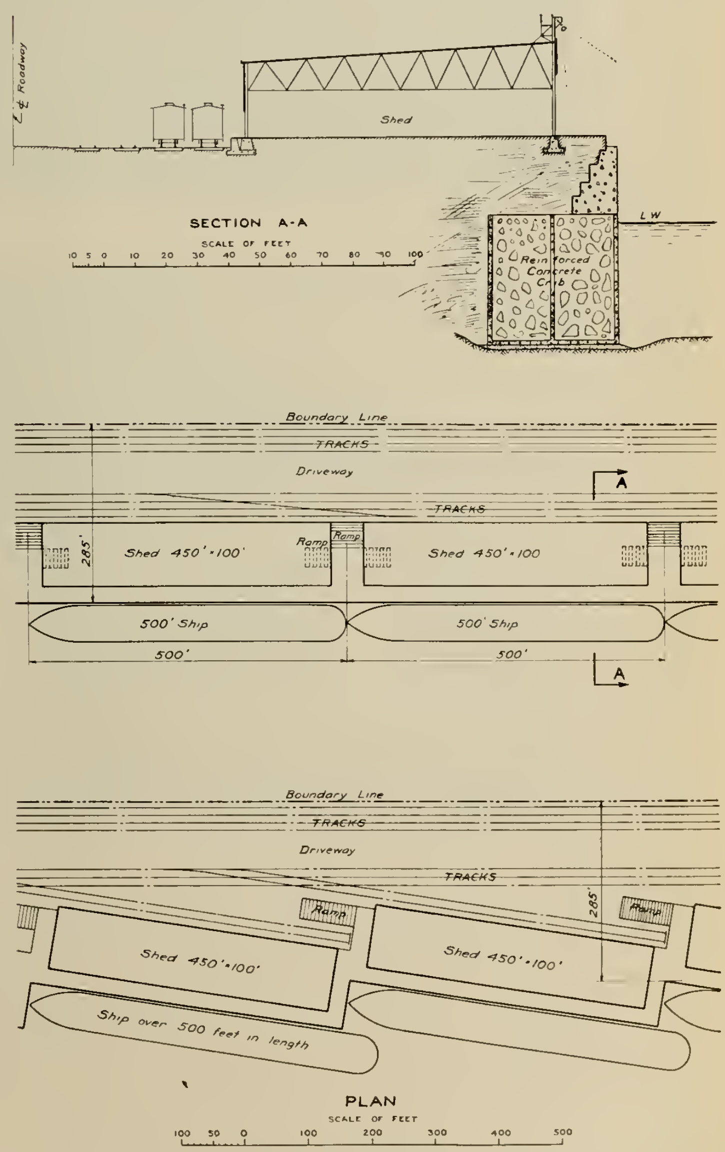


Fig. 8—Two Types of Shore Wharf Construction, Montreal Harbour.

and considering the presence of a strong current at these berths, their berthing and sailing when ships are already berthed at the adjoining upstream and downstream berths becomes a difficult and even dangerous manoeuvre. When berthed at a wharf of this description, ships are, during the whole period of their stay, subjected to the constant strain resulting from the action of the current, and the failure of one ship's moorings would likely endanger those of others moored downstream from her.

Through the rotation of each individual berth at a point located at its extreme upstream end, so as to form a recess between its downstream end and the adjoining berth (as in Fig. 8.), all these objections disappear. Ships of any length can be berthed at a given berth without interference with the adjoining one. Their berthing and sailing can be effected with comparative ease. The failure of the mooring of any particular ship would simply let her drift downstream without exerting any extra strain on the moorings of the ships below. The recess protects the bows of the ships from the effort of the current and creates an eddy counteracting to a certain extent the pull on their sides and sterns.

The retaining walls of these wharves, like many others in the harbour of Montreal, consist of reinforced concrete cribs topped with a gravity concrete wall, as shown in section A-A, Fig. 8. The cribs are founded at a depth of at least 36 ft. below the standard low water elevation and the top of the walls at approximately 25 ft. above the latter. The river bed on the site of the crib seat is first dredged to 12 in. below the elevation at which the crib is to rest. When this operation is completed, careful soundings are taken. When the bed has been found satisfactory, a layer of 2-in to 2½-in crushed stone, at least 12 in. thick, is spread over the seat as a mattress.

For the purpose of obtaining an even surface, a small scow has been fitted with a steel beam 45 ft. long suspended at the proper depth from the surface of the water, and a diver spreads the stone so that the beam can be passed over the mattress. Protuberances are removed and cavities filled. Soundings are taken in order to ascertain the quality of the work when completed.

It has been found necessary at places where there is too strong a current, to build up a wall of bagged concrete on the exterior side of the mattress as a prevention against scouring, particularly when, during the process of crib sinking, the crib nears the bottom. When the speed of the current is excessive, the top layer of the mattress stone must also be bagged for the same reason. The crib, conveniently ballasted, is then towed out, placed in position over the mattress, and sunk by filling it with water. The use of water ballast makes it possible, in the event of the crib not coming to rest on the proper alignments, to float it again for adjustment. Siphons or valves are resorted to for the purpose of filling the cribs with the required quantity of water.

Following the satisfactory placing of the crib on its mattress, it is filled with granular material, preferably of a fine nature which squeezes the water out more completely than a coarse one. The mass concrete cope wall is then constructed over the crib. An interspace of 30 in. is provided between contiguous cribs. It is closed on the outer face of the wharf and below the surface of the water, either by means of bagged concrete, a method suitable to any condition, or by a pre-cast reinforced concrete pile of convenient size and shape. A concrete bilge, integrally provided during the construction of the crib, runs from top to bottom of the crib at each end with its exterior face flush with the exterior face of the crib, in order to maintain in place the keys, whether formed of bagged concrete or pre-cast piles.

The dimensions of the reinforced concrete cribs built for incorporation in these and other wharves and provided therein as a subaqueous understructure, were fixed as height 42 ft., length 112 ft. and width 42 ft. This particular width was adopted as the largest one which would permit floating of the cribs through the Lachine canal along which are the docks where the contractors built the cribs. The length and height were chosen for convenience in the sinking of the cribs, and economy of design, respectively.

The construction of the cribs is not limited to the dry-dock method by any means. As a matter of fact, some of the early cribs were built on a specially built shallow pontoon of dimensions exceeding those of the cribs by approximately 3 ft. on each of the four sides. A sufficiently strong and rigid partition of a convenient height was provided on the four sides of the pontoon and the forms of the actual crib erected with both the pontoon and forms concentric. The concreting of the forms had for obvious effect the gradual submersion of the boat, consisting of the pontoon and its side walls, in the water. When the subsidence became sufficient for the water to invade the open space between the crib and the exterior wall over the latter, the crib was of a sufficient volume to float by itself. The pontoon was then loaded by means of heavy weights under which it sank to a depth not exceeding that necessary to pull the crib off the float or the float with its walls from under the crib. The removal of the weights caused the pontoon to rise to the surface ready for the start of a new crib construction.

Cribs have also been started on three scows tied together side by side so as to form a pontoon, the width of which was the length of the scows and its length the combined width of the three scows, an integral stiff deck being provided over the group of scows. When the cribs were of sufficient height to permit self floating, water was admitted into the scows, conveniently partitioned crosswise, and the eccentric weight of the volume of water, through the consequent canting on one side of the group of scows, allowed the crib work to slide into the water over a slipway provided and greased for the purpose.

Cribs have also been partly built over a convenient platform erected on the shore so designed as to allow canting sufficient for the sliding off of the crib work. When leaving the platform, the crib became supported on a greased slipway carried on a slant to a sufficient distance in the water as to allow the crib to float when reaching the end of the slipway.

In all instances, the floating cribs were raised to their definite height of 42 ft. in lifts so calculated as not to allow any fresh concrete to become submerged prior to its having had two days curing in the air.

In the design of the different parts of the cribs, consideration must be given to the following factors:—

The concrete and reinforcing steel of bottom slab or bilge which is required primarily for the sake of flotation of the crib prior to its sinking in place, must resist part of the reaction of the water against the weight of the completed crib. When the crib is floating, it is necessary to admit some water so as to maintain its stability and verticality during the raising and sinking processes. The weight of this volume of water reduces by so much the reaction the bottom slab would have to resist if the crib were maintained in an empty condition until sinking.

The crib has in plan the character of a series of contiguous bins, much like an ordinary reinforced concrete grain elevator. The transverse walls, 12 in. thick, are computed as retaining walls for a 5 ft. excess of fill between consecutive bins during the filling process only, the water admitted in the cribs prior to and during the sinking

Isle of Orleans Bridge, (*top*) over St. Lawrence River, six miles below Quebec City. Total length including approaches, 1½ miles. Suspension span, longest of its type in Canada, 1,059 feet centre to centre of main piers. Two side spans 419½ feet each.

Jacques Cartier Bridge, (*bottom*) built by the Board of Harbour Commissioners of Montreal over St. Lawrence River. Total length 8,817 feet including main span of 1,937 feet overall and 1,097 feet centre to centre of piers. Height above high-water 163 feet.

*Illustrations through the Courtesy of the*
Dominion Bridge Company Limited

process being maintained at a practically even level in all the bins, and also as buttresses taking the reaction of the water pressure on the front and rear walls during the flotation period.

Consideration must be given to the horizontal component of the stress in the front wall due to the interior fill and the pressure when the crib is finally part of the wharf structure, as affecting the design of the reinforcing steel of these walls and their end enchorage.

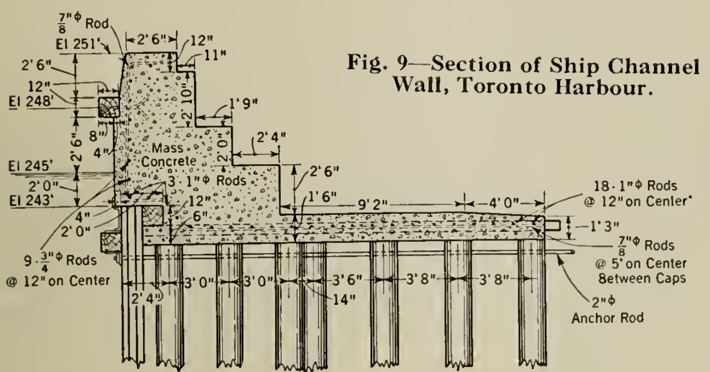

Fig. 9—Section of Ship Channel Wall, Toronto Harbour.

The central longitudinal wall is provided, at least in the central bins, merely as a stiffener for the cross walls. Being required for that purpose it is computed to resist the side pressure of a possible 5 ft. height difference of fill between the two sections of the bin it separates, and is used in the design of the bottom slab to take its proportioned share of the latter's upward reaction. Further, this wall strengthens both ends of the crib.

The rear and end walls are designed to resist part of the water pressure when afloat, that of the fill prior to the backfill behind and at each end of the cribs.

In the front wall consideration is given to exterior water pressure when afloat, and interior resultant of fill and superloads, plus vertical pressure of cope wall.

This wall is thickened by 6 in. as a protection for the reinforcing steel, laid 6 in. clear of the exterior face, against possible breakage of the concrete facing by shocks. It was also necessary to thicken the rear wall for the sake of stability when afloat during construction and sinking. The four exterior walls have a double horizontal reinforcing system, also the bottom slab, the others a single, while vertical spreader rods are provided. The front and rear walls are 22 in. thick, the end walls 24 in., the interior walls and the bottom slab 12 in.

A sufficient number of rods is also provided protruding past the top of the cribs, imbedded in the top wall concrete to resist the pull of the mooring cables on the bollards. The vertical rods, where the quay wall is resting on the walls, are left protruding over the top of the cribs.

Towing rings are provided for use in mooring or towing the cribs.

## TORONTO HARBOUR

During the past fifty years, the material changes which have taken place in the construction of ships have brought about the necessity of harbour improvement to keep pace with such changes. Vessels have kept on increasing in size and speed, the self-unloader has made its appearance and canals are continually being enlarged and deepened to meet the ever-growing demands of navigation.

In 1910, through lack of proper vessel accommodation, Toronto harbour was in some danger of losing what waterborne trade it possessed. Adequate improvement to meet the demands of navigation was an impossibility without legislation, which was obtained with the passing of The Toronto Harbour Commissioners' Act on May 19th, 1911. Under the provisions of this act five commissioners were appointed, three by the city council and the other two by the Dominion Government, one of the latter being nominated by the Board of Trade. They hold office for three years, are eligible for re-appointment, elect their own chairman and act without remuneration. The act gave them very wide powers and they were authorized to develop their properties.

Surveys were made and plans prepared, the latter being approved by the city council in November 1912, and by the Dominion Government in June 1913. This was immediately followed by the awarding of contracts and the commencement of the work which has been carried on continuously since that date. As a result Toronto now has a practically new harbour, modern in all respects and capable of accommodating the largest vessels which can pass through the Welland ship canal, as well as those which may, in the future, navigate a completed St. Lawrence deep waterway.

The carrying out of the above work comprised the construction of a ship channel and turning basin in the eastern section together with retaining walls on the Don Channel and Marginal Way, and the reclamation of the adjoining lands. Single leaf bascule bridges were erected over these channels.

This area, known as the Eastern Harbour Terminals, reclaimed from marsh lands and lands covered by water, now comprises 580 acres of land for industries, and is served by 20 miles of steam railway tracks, 8 miles of wide paved streets and 6½ miles of permanent concrete wharves. Nearly all of the area was non-revenue producing in 1915.

In the central section a new harbourhead line, at a maximum distance of approximately 1,100 ft. south of the old pierhead line, has been constructed easterly from the western entrance of the harbour to Yonge street. There is a bulkhead line from Yonge street to Parliament street, and the land to the north of it, from Bathurst street to Parliament street, has been reclaimed. Practically all of this was covered by water and non-revenue producing in 1917. This area, known as the Central Harbour Terminals,

Fig. 10—Marginal Way Pier, Toronto Harbour.

contains 260 acres of land for industries and is served by 8 miles of steam railway tracks, 4 miles of wide paved streets and 4 miles of permanent concrete wharves.

In the west end some 330 acres have been developed, of which 217 acres were reclaimed for park and recreational purposes and 113 acres for an improved waterway formed by the construction of a breakwater paralleling the shore at a distance of about 350 ft. and extending from the Humber river to the western entrance to the harbour, a distance of approximately four miles.

The retaining walls which formed a very large part of the work presented the most interesting features, their design being dependent upon the depth of rock below mean water level. The ultimate navigable depth of the harbour was thirty feet and where the rock was about this depth the crib type wall was necessary. Where the depth to rock exceeded 40 ft., a navigable depth of 30 ft. could be obtained by dredging; here the pile type of wall could be used and still leave 10 ft. for the penetration of the piling.

### Ship Channel Walls

The ship channel walls consisted of tongued and grooved close sheet piling of B.C. fir made up of 12 in. by 12 in. timber with strips spiked to both sides to form a close sheet piling. These piles were 40 ft. long and were driven along the front of the structure. They were then cut off square at an elevation of 243 ft., or two feet below the zero of the Toronto Harbour Commissioners' gauge. (Fig. 9.)

Along the top of this close sheet piling two stringers were placed, one along the inside or rear face of the pile and the other along the outer or front face; the rear stringer was 12 in. by 12 in. timber and the front stringer a 15-in. steel channel, and these two stringers were fastened together by one inch bolts.

Pile bents were driven at right angles to the line of the work to form the foundation and brace the sheet piling. These piles are of spruce 14 in. at the large end and 8 in. at the small end.

Anchor rods two inches in diameter and 50 ft. long were placed on 10-ft. centres extending from the front face of the timber sheet piling back to two anchor piles driven at 2-ft. centres, and each rod was provided with a turnbuckle.

The ship channel was unwatered to enable the proper cutting off of the piles, the setting of cap timbers and placing the superstructure, which latter was formed of reinforced mass concrete, and it also permitted a close inspection of the various stages of the work. The concrete was mixed in the proportion of one part cement, two parts sand, four parts broken stone or gravel and moulded in 50-ft. longitudinal sections with provision for expansion and contraction at each joint.

Cast iron bollards of the Scotch type were placed at distances of 75 ft. along the ship channel and turning basin walls.

Variations of this construction are to be found in the Polson Extension and Don Channel walls, parts of which were constructed with steel sheet piling, but the greatest variation is in the Marginal Way pier which has been recently constructed by the Dominion Government.

In this latter pier (Fig. 10), steel sheet piling was used throughout. A section, 31¾ lb. per sq. ft. and varying in length from 44 ft. to 56 ft., formed the outer face or front wall of the pier. This was cut off at an elevation of 248 ft. Six inches below the top of the pile a stringer formed of 12-in. by 4-in. steel channel weighing 36½ lb. per lineal foot was placed along the outer face of the front sheet piling and from the face of this stringer, two inch anchor rods 50 ft. long with turnbuckles and spaced at 8-ft. centres extended back to two anchor piles in a manner similar to the ship channel wall. Bents formed of round wooden piles 38 ft. to 45 ft. in length were driven at 5-ft. centres, at right angles to the sheet piling and carried back a distance of 21 ft. These piles, with the exception of the rear pile, were cut off at elevation 243.5 ft., the rear pile was cut off at elevation 246.5 ft., and along the rear face of the top of the rear piles was placed a 6-in. by 8-in. waling, forming a guide for an inner row of sheet piling, 18½ lb. per sq. ft. and 40 ft. long which was cut off at elevation 247 ft.; along the outside of the top of this sheet piling another 6-in. by 8-in. timber waling was placed. Half way between each anchor rod a 1½-in. tie rod extending from the face of the front stringer to the last mentioned waling fastened the two together. The superstructure was of reinforced mass concrete similar in proportions and form to that of the ship channel.

Along the inner harbour front where rock was encountered at a depth of about 30 ft. or less, the crib type of wall was used. It consists of rock filled cribwork in sections of standard length of 100 ft. and special lengths as required to make up odd distances. The section of these cribs was square, varying from 18 ft. to 26 ft. by two-foot intervals. In addition to the timbers shown on the general cross-section (Fig. 11) longitudinal ties were placed in all cribs over 24 ft. in width. Berths or trenches were dredged to bed rock. Before placing the cribs the rock was cleaned and levelled, careful soundings were taken and the crib constructed to fit the bottom as accurately as possible. After being sunk and held in place by sinking blocks, the cribs were lined and filled with stone; the various sections of the crib work were fastened together by interlocking end posts; and shoes, fastened to the face of each crib at every cross tie, were bolted to the rock with 2½-in. bolts.

A reasonable time for settlement was allowed before the vertical posts were cut off and capped and the flooring laid to receive the concrete superstructure. The elevation of the top of the wooden substructure is 243 ft. or 2 ft. below the zero of the Harbour Commissioners' gauge.

The superstructure consists of pre-moulded reinforced concrete blocks 8 ft. by 5 ft. by 5 ft. with sides bevelled front to back to ensure as far as possible a perfect alignment. After being placed and lined the blocks were keyed to the plank flooring and to each other. The concrete mass as shown in Fig. 3 was then placed on the

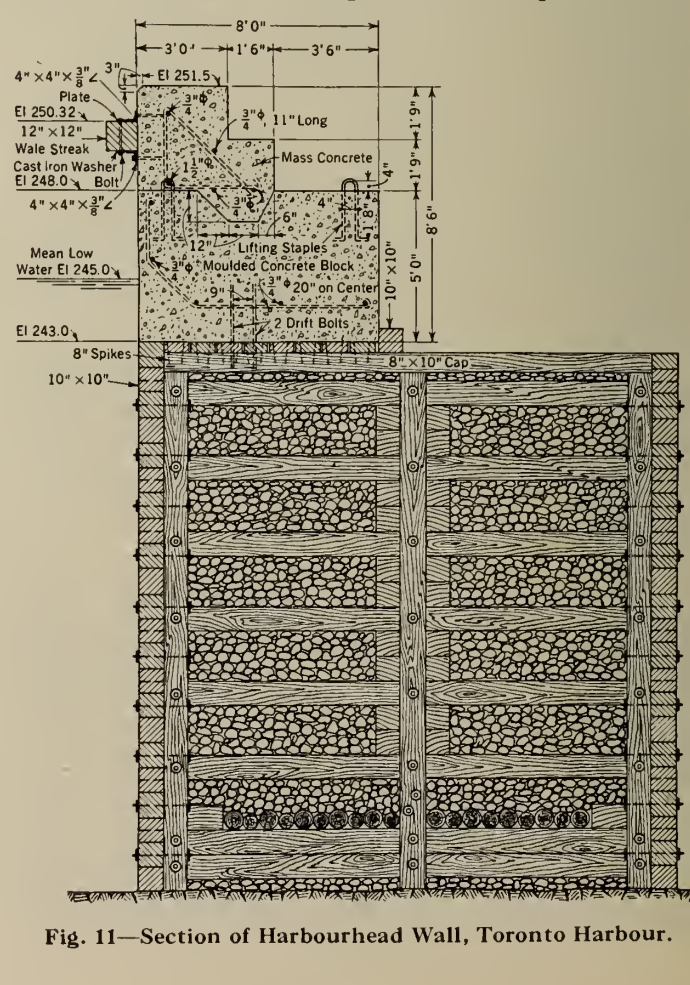


**Fig. 11—Section of Harbourhead Wall, Toronto Harbour.**

blocks and tied to them by reinforcing steel. Expansion joints were placed at every 50 ft. and mooring bollards every 75 ft. as in the case of other walls.

A similar type of wall with the exception of the extreme western section which is on sand, was used in the construction of the western breakwater (Fig. 12) which differed only in height and the form of superstructure. It is a structure 18,500 ft. long and extends from the mouth

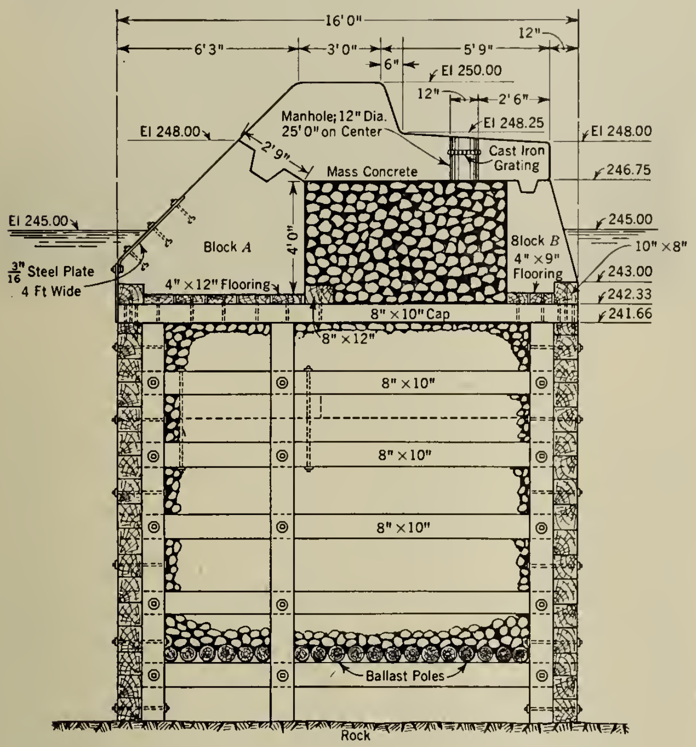


Fig. 12—Section of Western Breakwater, Toronto Harbour.

of the Humber river easterly to the western entrance to the harbour with intervening openings and was built for the purpose of preventing the erosion of the shore line from southerly gales and as a protected waterway.

As a result of the carrying out of these improvements the assessed value of the occupied harbour properties has increased from $1,976,804 in 1912 to $20,937,721 in 1936, and, during the same period, the city has received in taxes from above-mentioned properties the total sum of $7,355,740. The cargo tonnage in 1929 totalled 959,234 tons; in 1930 the Welland ship canal was opened to navigation, following which the cargo tonnage increased to 3,382,830 tons in 1936.

## DEEP SEA PIERS AT THE PORT OF VANCOUVER

### Lapointe Pier

The first permanent deep sea pier constructed in Vancouver harbour, now known as Lapointe pier, is located on the south shore of Burrard Inlet, and was designed by the Department of Public Works. Construction was commenced in October 1913 and completed in the fall of 1915. The pier, as constructed at that time, was 800 ft. long and 300 ft. wide. The berths are dredged to a depth of 35 ft. below low water, or to elevation 49.77, using the National Harbours Board datum. Thus elevation 84.77 is low water level and 97.77 high water. The cope level of the pier is 106.00. In order to obtain the required depth of water in the berths, it was necessary to dredge some 127,000 cu. yd. of material. At approximately 25 ft. below low water rock was encountered and a special drill scow with five drills was built with which some 200,000 yards of rock were removed and dumped in deep water. The pier is constructed with reinforced concrete faced timber cribs, consisting of twenty-three sections, each 99 ft. long, 40 ft. wide, and 39 ft. high. Each section of crib used approximately 500,000 ft.b.m., of B.C. fir. 1,550 cu. yd. of reinforced concrete, and 28 tons of reinforcing steel. The crib sections were constructed on launching ways to a height of 10 ft. and the concrete facing to a height of 8 ft., after which they were launched and then built up to their full height of 35 ft., floated into location and sunk into position. Upon the crib-work substructure was built a solid mass-concrete gravity retaining wall with a height of 18 ft., base of 13 ft. and top of 6 ft. This wall runs around the two sides and north end and forms the cope of the pier. Approximately 15,000 cu. yd. of concrete were used in this portion of the work. 400,000 cu. yd. of gravel were used to fill the cribs and bring the core of the pier up to cope level. The Lapointe pier, as built in 1913 and described above, is provided with grain galleries and the necessary spouting for loading grain direct to ships. Two sheds were built of mill construction, shed No. 1 being 676 ft. long by 79 ft. wide, and shed No. 2 being 842 ft. long by 98 ft. wide. The pier is provided with the usual trackage, which connects to the National Harbours Board Terminal Railway. The aerial view in Fig. 13 shows the pier before extension.

Due to the increasing length of the modern deep sea vessels, it was found that the pier was of insufficient length to accommodate two vessels on each side, and it was accordingly decided in 1933 to extend it by 310 ft., making the total length 1,110 ft. The type and method of construction was somewhat similar to the original work but in place of facing the four sides of each crib with concrete, only the water side was provided with a concrete face, the other three sides, which were eventually embedded in the fill, were merely sheathed with a double layer of creosoted lumber and made sufficiently water-tight to keep afloat during construction. 127,000 cu. yd. of mud and silt were cleaned from the site in order to obtain a solid bottom on which to place the foundation fill. The removal of soft material was essential by reason of the depth of water (90 ft. at low water), and to obviate the possibility of the gravel foundation fill and structure sliding after construction. The quantity of material used in the extension, comprising eight cribs, was approximately 4¼ million feet of B.C. lumber; approximately 300 tons of reinforcing steel, drift bolts, etc., and 9,000 cu. yd. of reinforced and mass concrete. The gravel fill required, including foundations, filling of cribs, and bringing the core to cope level, was 432,000 cu. yd.

It is interesting to note that the maintenance on the original structure built in 1913 and the extension built in 1933 has been very small.

### Ballantyne Pier

The Ballantyne pier is also located on the south shore of Burrard Inlet, and was designed and the work supervised by A. D. Swan, M.E.I.C., of Montreal. Construction was commenced in 1920 and completed in 1923. The length of the pier is 1,200 ft. on the east side and 1,070 ft. on the west side, the width of the pier being 341 ft. The inner berths are dredged to 35 ft. below low water and outer berths dredged to 45 ft. below low water. The elevation of the cope of the pier, N.H.B. datum, is 106.00. The pier is of reinforced concrete—beam and slab construction—supported on concrete cylinders, carried down to bed rock. The cylinders are seven feet in diameter, with a 9-in. wall. They were pre-cast in sections averaging 17 ft. in length. The bottom section was provided with a steel cutting edge which, in some instances, was enlarged to 9 ft. outside diameter, where additional bearing area was advisable. The cylinders were sunk through the fill by open dredging method, orange-peel buckets being used. The cylinders were located 20 ft. centre to centre longitudinally with the pier and 32 ft. transversely, to conform with the positions of the transit shed columns. They were sunk in position and filled with concrete. Approximately 85,000 cu. yd. of soft material was removed and 70,000 cu. yd. of rock excavated. The gravel core fill approximated 700,000 cubic yards. The pier is provided with three two-storey reinforced concrete sheds 108 ft. wide by 400 ft. long. The pier and sheds are served by seven railway tracks running its full length, and connecting with the National Harbours Board Terminal Railway. Thirteen electrically operated travelling cranes of three-ton capacity are provided for the handling of ships cargo. Grain conveyor galleries are located on the roofs of the sheds and several of the cranes on each side of the pier have been specially adapted for carrying grain from the galleries by means of spouting to the ships. This enabled the grain galleries to be carried at a low level, thereby very materially reducing the height of the steel towers and the overturning moment due to wind load. This in turn substantially reduced the foundation requirement. Approximately 96,000 cu. yd. of concrete were used in the entire works, and 6,100 tons of reinforcing steel. The pier is shown in Fig. 14 and is equipped with every modern appliance for the expeditious handling of cargo.

It was found during construction that all phases of the work proceeded in accordance with schedule except that of sinking the cylinders. Below the stabilizing fill and lying above the sandstone and conglomerate foundation, a considerable number of boulders were encountered. These materially delayed the completion of the sinking operations. Considerable time and expense would have been saved had the entire area been dredged free of these boulders before placing the stabilizing fill. This was done with satisfactory results on the No. 2 elevator foundation nearby, the construction of which followed the building of the Ballantyne pier.

Fourteen years of maintenance have shown some minor defects but in general the pier construction has remained in exceedingly good condition. The only deterioration in the concrete sub-structure has been found where the pre-cast trusses join the cylinders. Here some repair work has been necessary due to corrosion of the reinforcing steel.

Fig. 14—Ballantyne Pier, Vancouver Harbour.

The stabilizing fill continued to settle for several years after completion of the work and several breakages occurred in the flanged watermains which were laid in the fill. A flexible joint, or preferably a separate trench in which the watermains could have been suspended would have been advantageous. The same subsidence also caused a settlement of the inner bay in the transit sheds, resulting in a fracture of the floor slab along the line of the inner row of columns. Concrete roadways were constructed approaching the pier structure and between the transit sheds. Considerable abrasion resulted from the use of trucks and trailers in handling cargo between sheds, and this section of roadway had finally to be paved with an asphaltic concrete. Sand lime brick was used in the inside panels of the wall construction. These were unable to resist the driving rains of the coast and a plaster coat for waterproofing purposes had later to be added. The drainage system has had to be amplified to take care of the heavy rainfalls, the down spout system being materially increased over the original.

Fig. 13—Lapointe Pier and No. 1 Grain Jetty, Vancouver Harbour.

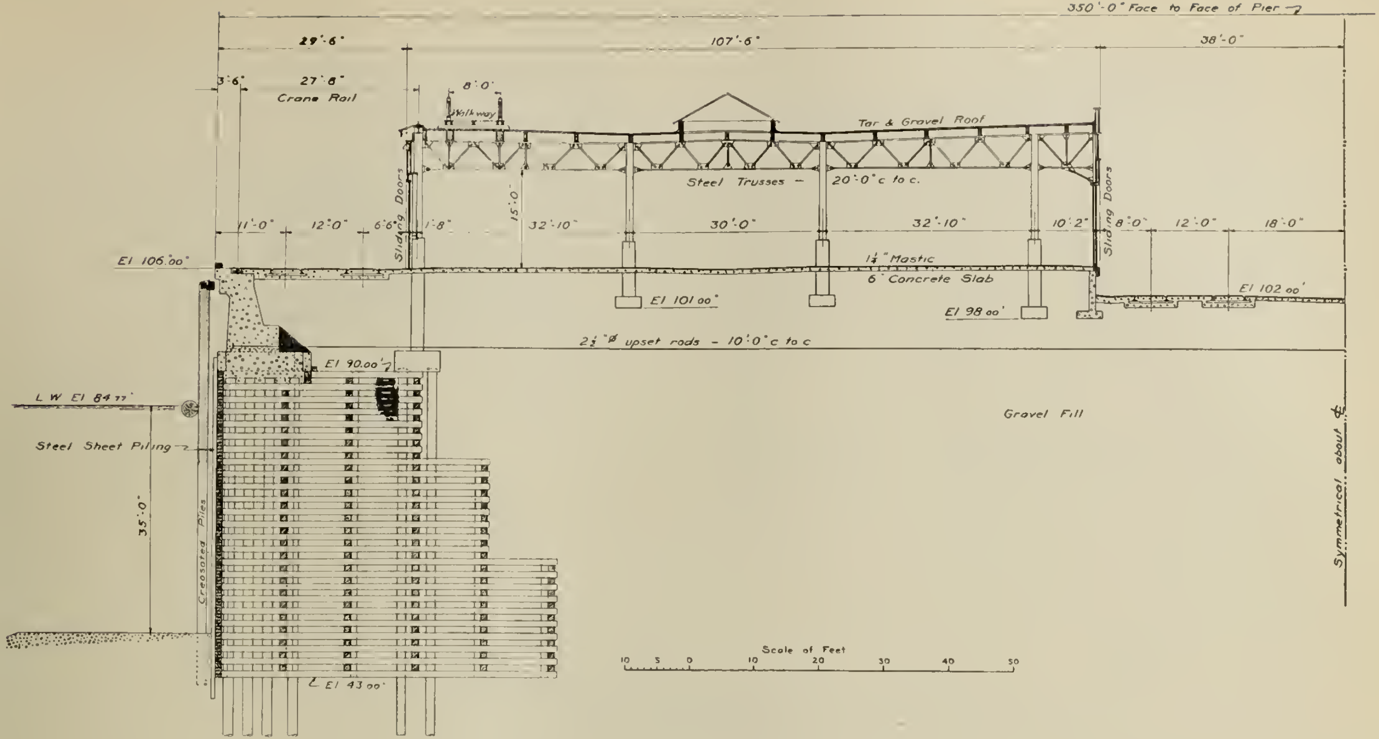


Fig. 15—Proposed Deep Sea Pier, Vancouver Harbour.

The value of the second storey in the transit sheds has been open to considerable discussion. At times the space had been almost entirely occupied with canned salmon storage. Its principal value lies in storing cargo where delayed shipment occurs. The lighting system has been entirely satisfactory in permitting the convenient handling of cargo. The wide pier apron has also been valuable for the expeditious handling of cargo. The width of the pier is ideal for the Pacific coast type of cargo.

### Proposed Deep Sea Pier, Vancouver Harbour

In the year 1929 Sydney E. Junkins, M.E.I.C., and the author were commissioned by the Vancouver Harbour Commissioners to prepare plans and specifications for a new deep sea pier to be located in the inner harbour of Vancouver on a centrally situated property of the Commissioners. Fig. 15 represents this pier in cross section.

The plans provide for the accommodation of deep-sea ships by the construction of a pier to the west of and adjacent to the existing Ballantyne pier. They contemplate a pier 350 ft. in width with a length of 1,547 ft. on the east side and 1,100 ft. on the west side, together with a connecting quay wharf, 320 ft. long. of creosoted piling and creosoted lumber across the end of the basin between the proposed pier and the Ballantyne pier.

The substructure of the pier will consist of a gravel fill retained by timber cribs surmounted by concrete walls on the outer edge. The timber cribs will be sheathed on the outboard face with interlocking steel sheet piling to protect them from marine borers. The space between the sheet piling and the timber cribs will be filled with sand. The substructure will have a spring fender system of creosoted piling.

The superstructure of the pier will consist of two transit sheds each 107 ft. 6 in. wide by approximately 1,062 ft. long. There will be a walkway along the roof of each shed on the outboard side for the accommodation of passengers.

At the south end of the westerly shed the necessary passenger accommodation will be provided, consisting of a baggage room and lunch room on the ground floor and a concourse, toilets, customs examination room and offices on the upper floor. The upper floor will connect with the walkways on the roof.

Along the outboard side of each shed there will be two railroad tracks and a track for semi-portal cranes.

Between the sheds there will be an area 76 ft. wide which will be depressed approximately 4 ft. below the floors of the sheds. In this area there will be a centre drive-way with two railroad tracks on each side adjacent to the sheds.

The surface of the pier and connecting roadways will be paved with concrete which will have a bituminous wearing surface.

The mechanical equipment of the pier will include a number of semi-portal cargo cranes and four marine elevators.

Crib construction of the type contemplated for this project has been used on several occasions in water front works in Vancouver harbour. Generally the cribs are partially completed on marine ways, launched and completed as a floating undertaking near by the site of the works. They are sunk by adding to the compartments a sufficient amount of sand and gravel filling to accomplish this purpose. In the case of the design in question certain parts were only to be partially filled originally, with the flooring of such thickness that the anchor and bearing piles would pierce these floors in driving.

In Vancouver harbour it has been the custom to protect the face and ends of these cribs against teredo action with concrete curtain walls. The principal variation in this case consists of the employment of interlocking steel piling driven around the entire outer face of the pier structure, having a minimum clearance of 3 in. from the crib timber, the top made fast to the concrete gravity section wall and the space between the steel piling and the crib timbers filled with sand to act as a filter for protection against marine borers.

The plan provides for the filling of the enclosed area hydraulically with sand and gravel of suitable consistency.

With respect to equipment, cargo cranes are fairly well known in Canadian harbours. Marine elevators,

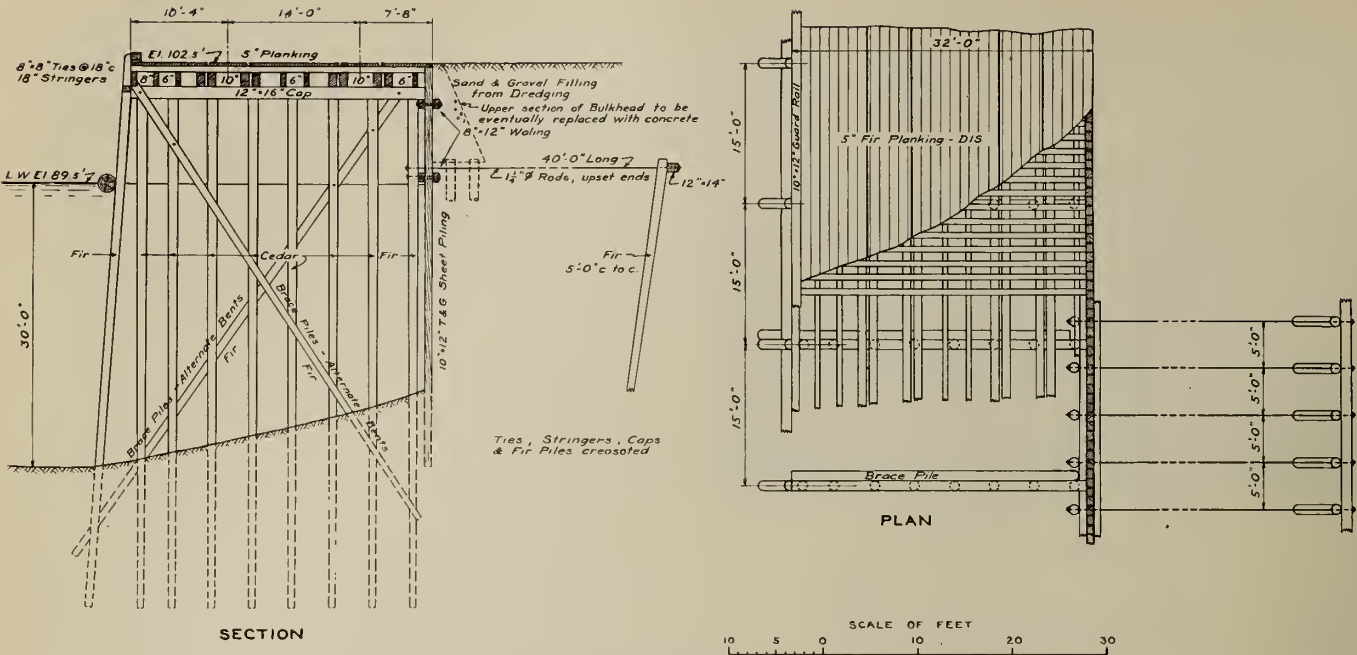


**Fig. 16—Typical Wharf and Bulkhead Construction, New Westminster, B.C.**

however, appear at the present time to have been made use of to any great extent in Vancouver harbour only. These consist of heavy platforms operating from the apron level of the pier to the deck level of lighters or of ships provided with side hatches, the stage of tide determining the extent of the lift. They are built of sufficient strength to permit the movement thereon, when resting at apron level, of railway cars and switching locomotives. They may be altered to act as ramps when the deck of the ship on which discharge and loading of cargo is proceeding is reasonably close to the apron level.

Due to the falling off of business in the year 1930 and the subsequent years of less than normal trade, the Commissioners decided to postpone indefinitely the construction of this pier. The site was, however, dredged free of soft material and the stabilizing fill, consisting of 1,200,000 cu. yd., has been completed.

## NEW WESTMINSTER HARBOUR

### Typical Wharf Construction

The port of New Westminster comprises the main channel of the Fraser river from the mouth to the confluence with the Pitt river, a total distance of 22 miles. In the past year, 1936, the business of this port in tons of cargo handled stood third in the Dominion.

Wharf or shore quay construction alone is suitable for the lower Fraser river. In many cases a wharf built on the bank of the river answers all requirements, but more frequently dredging is required. This can be economically combined with filling in rear to complete the area required for tracks, storage and other industrial purposes. The development cost is low, and except where heavy erosion of banks threatens, is very satisfactory.

The type of wharf construction shown in Fig. 16 has been satisfactorily employed in several projects, although generally creosoted materials are not initially adopted. There are no marine borers present so far in the lower Fraser river. Red cedar piling is therefore very durable and many structures of twenty-five years' life and over are to be found with 12 in. to 15 in. only of deterioration of cedar pile tops under the cap. The balance of the piling shows very little deterioration.

Many types of timber bulkheading have been used but the design in question has been tried and found eminently satisfactory. It is designed not only for the final loading but to resist hydraulic pressure during construction, since most of the dredging and filling operations in the port are carried out by hydraulic equipment. Care is taken, however, during the filling operations to avoid impounding water from the pumping behind the bulkheading.

Provision has been made in this design for cutting off and replacing by a concrete retaining wall that portion of the bulkhead above the lower tie rod connection. This is due to the deterioration and eventual destruction of the timber above the permanent wetted level.

Untreated wooden flooring has been found to be decidedly uneconomical and is giving way to an asphaltic concrete suitably supported on laminated construction. It has been found imperative to leave a half inch air space in the laminated base, otherwise dry rot is inevitable. This type of wharf is in general designed for standard railway loading less impact allowance, and where tracks are omitted for 500 lb. per sq. ft. live load. The foundation material is fine river sand, progressive refining occurring towards the mouth of the river. Skin friction alone supports piling which has an average penetration of 35 ft. Maximum pile loading of 25 tons per pile has been adopted as having a sufficient factor of safety. Piling varies from 9 in. tops to 15 in. butts. Eight pound creosote treatment of timbers appears to be satisfactory.

# Surveying and Mapping

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Probably no science can claim progress that is not intimately linked with agencies developed by other sciences and in few engineering activities is this more emphasized than in Canada's progress in surveying and mapping through the past fifty years. Progress in these related activities has been tremendously increased, methods improved and costs reduced by practical and far reaching discoveries in the fields of electricity, metallurgy, chemistry and physics, and mechanics.

In the electrical field, communication by wireless through radio signals has brought speed and accuracy to astronomical observations; in metallurgy the discovery of invar with an almost negligible coefficient of thermal expansion has given increased accuracy in the direct measurement of distance; in chemistry and physics the introduction of infra-red photography and echo-sounding apparatus respectively have had tremendous beneficial effects; and in the great field of mechanics the internal combustion engine, the aeroplane and the modern aerial camera have combined to give swift transportation and accurate and extensive topographical information at greatly reduced costs. Yet in looking back over fifty years, there is the striking fact that while modern instruments have given increased precision, the spectacular advance has been made in the use of faster and less costly methods.

The surveyor or engineer of fifty years ago was as interested in keeping the human factor of error to a minimum as his successor of to-day and the results obtained in the early surveys command admiration and respect.

Many years before 1887 Canada's surveyors were busy with the opening up of a new country, some on land surveys, some on river control and reclamation projects, some on road and railroad location. Many went west during the early eighties when the Canadian Pacific Railway was under construction. In British Columbia they followed the Royal Engineers who in 1858 brought the first surveyors to that province. Throughout Canada and particularly in the western provinces these pioneer surveyors contributed greatly to the country's development. Their works bear witness in many localities and their names are perpetuated by river or mountain or town across the Dominion.

Because of her youth and tremendous unmapped areas, Canada has perhaps benefited more than any other nation through the development of modern survey and mapping methods. Nor has this country failed in itself to contribute substantially to such development. Possibly the greatest single advance in mapping work, namely, photo-topographical surveying, was developed for practical use in Canada by the late Dr. E. Deville, for many years Surveyor General of Dominion Lands. Another important contribution towards placing surveying practices on a sound basis was that of the late Dr. W. F. King, Chief Astronomer, International Boundary Commissioner and Superintendent of the Geodetic Survey of Canada. A bronze tablet on the summit of King Mountain, a few miles north of Ottawa, marks the beginning by Dr. King at that point of the geodetic triangulation network in Canada.

### Survey Organizations—Historical

To obtain a clear picture of the advances in surveying and mapping during the last half century, one must understand something of the evolution of the Canadian


**Fig. 1—Map of Eastern Canada. Reproduced from a Map by Duchesneau dated 1681.**

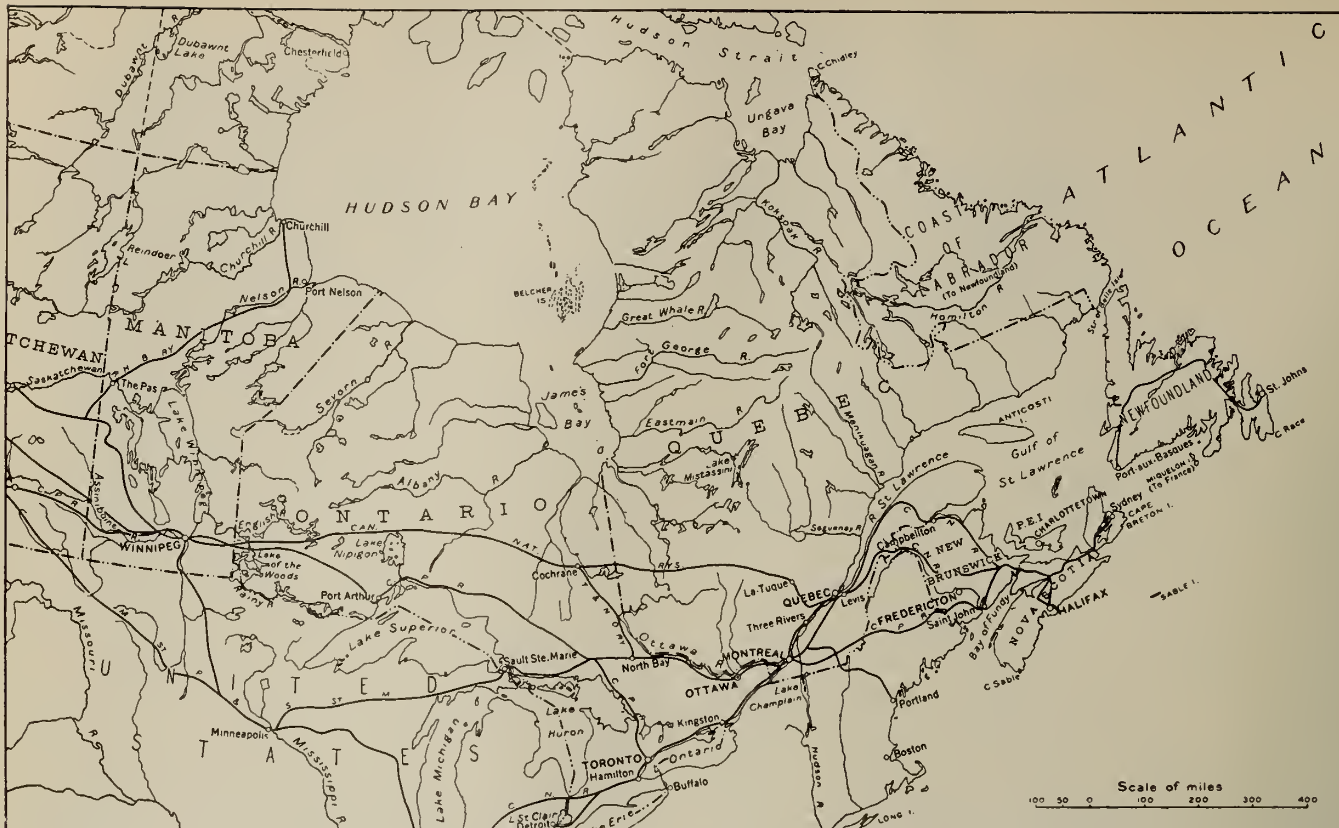


Fig. 2—Map of Eastern Canada 1937.

Survey organizations. Under the terms of Confederation the administration of their natural resources was a responsibility of the various provinces of the Dominion and hence the execution of the cadastral surveys, that is, the subdivision of provincial land into units for agriculture, forestry, mining or other uses was and still is a function of the provincial governments. Federal authorities, however, continued these surveys in the provinces of Manitoba, Saskatchewan and Alberta and in the Railway Belt and Peace River Block of British Columbia until 1930. In that year the four western provinces, under the Transfer of Natural Resources Agreements, took over the administration of all provincial lands within their boundaries, including the undertaking of land surveys.

Much of the mapping done prior to 1887, and for many years afterwards, was thus based on information secured by Dominion Land Surveyors in carrying on cadastral surveys and from other surveys undertaken by Provincial surveyors. An exception to this was the topographical work undertaken by the Geological Survey of the Dominion Government. Established in 1842, this organization issued topographical maps in order to locate and show geological data. For the next fifty years many of the best topographical maps that were available came from this source and at the present time a large proportion of topographical surveying in Canada is undertaken in connection with the work of this unit.

While surveys of water routes and other physical features naturally supplied additional information, topography was for many years more or less a secondary consideration.

After the first organized land survey in Canada was commenced in Prince Edward Island by Captain Samuel Holland in 1764, the magnetic compass continued as an important survey instrument for over a hundred years, or until 1870. The following year, 1871, the first monument of the Dominion Lands Survey System was placed on the Principal Meridian.

Prior to 1883 all charting of Canadian waters was carried on by the British Admiralty. In that year the Hydrographic Service of Canada was organized. Its operations were confined to the Great Lakes until 1904. In that year the Canadian organization commenced operations on the Atlantic coast and in 1906 undertook the work on the Pacific coast.

In 1886 a start was made in mapping sections of the Rocky Mountains by photo-topographical methods. This method of mapping has been much more extensively used in western Canada than in any other country and with some improvements has remained in use to the present time.

While by 1887 the several sections of the International Boundary between Canada and the United States had already been defined in a series of treaties, demarcation was only partial, and the nature of the marking was such that it was in many cases rapidly disappearing. Water sections of the boundary were practically unmarked, no accurate maps of them were available, and in addition the boundary between Canada and Alaska had yet to be determined. As a result of these conditions, the past fifty years has seen the entire International Boundary between Canada and the United States and between Canada and Alaska surveyed. and a belt along the boundary mapped.

Figure 3 is a view looking eastward along the International Boundary at Fort Frances, Ontario, and International Falls, Minnesota; Rainy river in the foreground, Rainy lake in the distance.

In 1891 the first sectional sheets on a scale of three miles to one inch were prepared from Dominion Lands Surveys and additional information gradually made possible accurate topographical maps of the settled lands in the prairie provinces. Compiled maps of Canada and of sections of Canada were being prepared from time to time so that in 1903 the first standard topographical map appeared which covered a portion of Ontario. This type of map, issued by the Chief Geographer of Canada, eventually covered most of eastern Canada and parts of British Columbia.

The Geodetic Service of Canada was officially created in 1909 but had already begun in 1905 the precise levelling and primary triangulation that were to form the framework of accurate control for all survey work in Canada. While proved in value by world experience and while particularly necessary because of her tremendous areas, Canada was nevertheless one of the later countries to initiate national geodetic control.

Following the Great War, national mapping in Canada was given its greatest impetus through the agencies of the aeroplane and the aerial camera. Experiments in vertical and oblique photography initiated by an Air Survey Committee appointed in 1919, showed in succeeding years the great possibilities of the new methods; the year 1924 saw the practical adaptation of aerial photography to surveying and mapping on a large scale. In the thirteen years of the new science of mapping, areas have been photographed to an extent undreamed of—and in fact impossible—with the old ground methods.

By vertical photography there have been covered to date 187,800 square miles; by oblique photography 505,000 square miles, or a total area almost equal to the combined areas of France, Spain, Germany and Italy.

No outline of the past fifty years of surveying and mapping in Canada would be complete without some mention of precise levelling and of the compilation "Altitudes in Canada." In early days elevations in the interior were at best approximations only, being based on aneroid readings or level lines of the early railroads. Levels for engineering projects were based on the best datums available and in many cases assumed datums were the basis for all levels in a locality.

The first precise levels in Canada were run by the Department of Public Works in 1883 to furnish accurate vertical control for harbour and river improvements, this net being largely confined to the St. Lawrence river and the Great Lakes. In 1931 this levelling system was amalgamated with that of the Geodetic Service.

In 1912 the Topographical Survey of Canada started precise levelling in the three prairie provinces to check and reduce to mean sea level datum the great mass of levelling information resulting from tertiary levels which were being carried on with the original land surveys. In 1925 this system of levels was also amalgamated with that of the Geodetic Service.

The original "Altitudes in Canada" appeared in 1901 and was compiled by the late James White when a member of the Geological Survey of Canada. Probably no government publication has been received with greater avidity; practically every engineer in the country had long felt the need of such information. Following the great expansion of railroads between 1901 and 1915, the second edition of "Altitudes in Canada" was printed in 1915 and contained much more than double the information available in the first work. In 1925 all of Mr. White's records were turned over to the Geodetic Service and several volumes covering parts of Canada have lately been issued or are in course of preparation.

In 1936 the survey organizations of the Federal Government were brought under the newly created Department of Mines and Resources, with the exception of the Geographical Section of the General Staff of the National Defence Department which undertakes considerable topographical work in order that a survey nucleus may be available in times of emergency.

To summarize the situation it might be said that at the present time all the cadastral survey work in the provinces is undertaken by them or under their control. The Dominion Government undertakes all cadastral surveys in Dominion areas including the Northwest and Yukon Territories. The Dominion also undertakes the main geodetic nets of triangulation and precise levelling and all hydrographic surveys.

In the field of mapping, British Columbia through photo-topographic surveys in her mountain areas makes an important and extensive contribution. The province of Quebec also issues a number of maps based on aerial photographs and other survey information. Elsewhere mapping is largely being undertaken by the Dominion, particular attention being paid to areas where natural resources such as mining and water power promise development. Excellent co-operative assistance is provided by the provinces through their cadastral and other organizations. At least three provinces—Quebec, Ontario and British Columbia—publish geographically compiled provincial maps, but otherwise the issuing of topographical and geographical maps, and of charts, is largely undertaken by the Dominion.

### Progress of Mapping

Some idea of the achievement in mapping to date may be given by a brief description of the three most important series of systematized topographical map sheets that have been issued by Dominion organizations. The sectional map sheets of western Canada, which have been extremely useful over many years, cover about 4,320 square miles. A total of 121 sheets have been issued. The Geographer's Standard Topographical Map was issued at scales of 3.95 miles to the inch and 7.89 miles to the inch, each sheet covering 7,500 square miles and 30,000 square miles respectively. A total of 56 of these sheets has been issued, mainly covering eastern Canada. This class of maps has now been discontinued and is replaced by what is called the National Topographic Series. The sheets of this series are of uniform size. The one mile to one inch sheet covers about 400 square miles, areas of other sheets varying with the scale. Of the large scale mentioned—one mile to one inch—150 sheets have been issued, chiefly by the Geographical Section of the National Defence Department. Of the two miles to one inch

**Fig. 3—International Boundary between Ontario and Minnesota at Fort Francis.**

sheet, 62 have been published; of the four mile sheets—58; of the eight mile sheets—9.

For convenience a table has been prepared—Table I—giving the area of Canada that has been covered by accurate maps at varying scales up to four miles to one inch.

Among important topographical maps that naturally have not been produced in a systematized or grid series are those of the Geological Survey for depicting geological information, and the hydrographic charts which cover Canada's sea coasts, waterways and harbours. The latter number some 480 and include standard mariners' charts for navigation, special charts for radio direction finding purposes, current charts and charts for general marine information.

## COMPARISON OF SURVEY METHODS—1887-1937

### Magnetic Surveys and Azimuth Determinations

Although the magnetic compass and the magnetic meridian had been partially superseded for the running of survey lines by the transit theodolite and astronomical meridian in 1887, yet the former has continued, to a small degree, even to the present time.

The uncertainty of compass readings due to diurnal and yearly variation, but more, perhaps, to the local attraction of magnetic substances, is very great, and many compass lines, if viewed from above, would appear snake-like instead of straight. It is easily realized that in any compass survey of large areas, when linear inaccuracies are also taken into account, errors of position of the order of several miles may easily result.

Although the use of the astronomic meridian as the basis of azimuth was in use fifty years ago, the instruments and methods were cumbersome and slow as compared to present-day practice. The telescopes of the average surveyor's transit of that day were not sufficiently powerful to observe on the Pole Star in the day time, and even if they had been considerable computation was necessary, so that surveyors in those days usually preferred to observe at night when the star was at elongation. Many surveyors will vouch for the inconvenience and tribulations attendant upon these night observations.

Let us consider now the advantages the present-day surveyor has over his predecessor of fifty years ago. Improvements in optical parts of theodolites now permit a sight on Polaris at any time of the day. There is no difficulty in seeing a star with any present-day surveyor's theodolite within an hour or two before dusk, or after dawn, when there is still sufficient daylight for all ordinary operations. Surveyors are further provided with mathematical tables that give the azimuth of the star at each ten minutes of time within the twenty-four hours and for different latitudes. With a modern transit-theodolite and sidereal watch a surveyor can orient his telescope to sight on the star in broad daylight, take one or two observations by the most approved methods in a few minutes, and by the aid of astronomical field tables quickly reduce the observations, the resulting azimuth being correct to within a few seconds.

The changing of the basis of direction for survey lines from magnetic to astronomical bearings, and the simplifying of the azimuth observations, are perhaps among the most important developments of the past half century in the improvement of cadastral and mapping surveys.

### Longitude Determinations

Modern agencies have also greatly simplified the determination of longitude as compared with fifty years ago. At that time astronomical observations for latitude had already reached a high degree of precision, but those for longitude were seldom as satisfactory.

The most accurate method of determining longitude required an exchange of time signals over a telegraph line between a point of known longitude and the one whose position was required. Consequently north of the telegraph lines near Canada's southern border, the only methods of determining differences of longitude were by the transportation of chronometers and by lunar methods, both of which were subject to considerable errors, and the latter method was arduous and slow.

Unknown variation in the rating of chronometers could result in large errors. This is exemplified in the case of early charts of the east coast of Hudson Bay where recent determinations of longitude show an error of the shore line given on the old charts of some 30 miles. In determination of longitude by lunar methods the most painstaking care was necessary to ensure reasonable accuracy. This is well illustrated by the accomplishment of the late William Ogilvie just fifty years ago in determining the point where the 141st meridian crossed the Yukon river in the Yukon Territory, information which was to be used in fixing the Canada-Alaska boundary. Lacking telegraphic communication and with the transport of chronometers not feasible, Mr. Ogilvie was dependent on lunar methods for his determination of longitude. Following a micrometer traverse from Lynn canal over Chilkoot Pass and down the Yukon river, Mr. Ogilvie established winter quarters at the 141st meridian as determined from his traverse. During the winter of 1887-88, he determined the longitude of his station by the method of moon culminations. When eighteen years later the longitude of the meridian was determined through telegraphic exchange of time signals,

Table I

Areas Mapped in Canada to Various Scales

| Scales | Accurate contours Sq. miles | Percentage of Canada | Approximate contours Sq. miles | Additional Accurate planimetry Sq. miles | Total Accurate planimetry Sq. miles | Percentage of Canada |
|---|---|---|---|---|---|---|
| Up to and including 1 mile to 1 inch | 71,960 | 1.9 | 4,800 | 700 | 77,460 | 2.1 |
| Between 1 and 2 miles to 1 inch (including 2 miles to 1 inch) | 25,800 | 0.7 | 9,800 | 48,800 | 84,400 | 2.3 |
| Between 2 and 3 miles to 1 inch (including 3 miles to 1 inch) | 9,800 | 0.3 | 155,200 | 8,200 | 173,200 | 4.7 |
| Between 3 and 4 miles to 1 inch (including 4 miles to 1 inch) | 63,000 | 1.2 | 66,000* | 310,900 | 388,600 | 10.6 |
| Totals = Areas up to, and including 4 miles to 1 inch | 170,560 | 4.1 | 235,800 | 368,600 | 723,660 | 19.7 |

Additional mapped to an intermediate accuracy ........ 15.0%
Mapped from very meagre information ........ 65.3

100%

*51,300 square miles planimetry, approximate only.

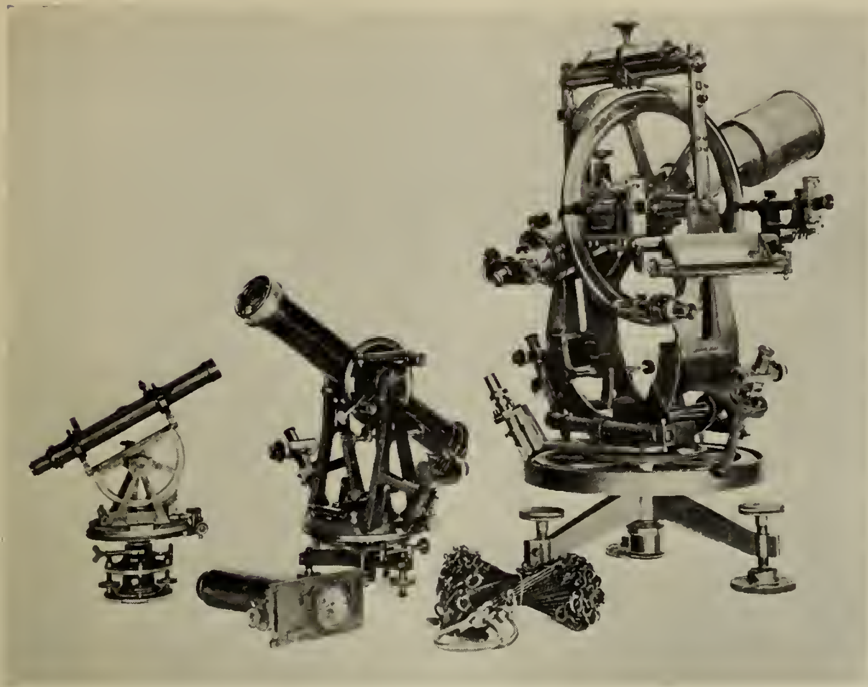

Fig. 4—Old Types of Surveying Instruments.

In Fig. 4 reading from left to right the instruments are: old type of theodolite; split lens type of micrometer used for distance measurements, accuracy about 1 in 200; micrometer theodolite for running governing survey lines, horizontal circle reading to 10 seconds, vertical circle reading to one minute; 100-link Gunter's chain; 12-inch altazimuth used for high precision astronomical work and primary triangulation, horizontal and vertical circle readings to one second. The old instruments are all characterized by great weight and long telescopes, and may be compared with the lighter short telescope modern instruments shown in Fig. 5. The scales of Fig. 4 and 5 are approximately equal.

Figure 5 shows: upper row—sounding sextant reading to one minute; precise level. Lower row—Prismatic astrolabe for astronomic latitude and longitude; surveyor's transit, horizontal circle reading to 20 seconds, vertical circle to one minute; transit theodolite for high class surveys, horizontal and vertical circles reading to one second; primary triangulation theodolite both circles reading to 0.2 seconds. The introduction of the internal focusing lens permitted great shortening of telescopes, and this and other improvements have allowed great reduction in size and weight to be made, with increased precision.

Mr. Ogilvie's position was in error only 218 feet, a truly remarkable achievement, but one involving a large amount of time and labour.

Present-day methods after fifty years are startling in their ease and simplicity. In 1936 during aeroplane mapping by oblique photography of the Northwest Territories, and with astronomical latitude and longitude used as a basis for aerial mapping, two observers determined the positions of thirty points in two summer months. Aeroplane transportation was provided by the photographic planes; each party was equipped with a radio transceiver with which the observers were able to receive accurate time signals from sending stations on two continents; and daily two-way telegraphic communication was maintained with the aeroplane base.

Precision of astronomical observations for latitude and longitude is not absolute, due to the deflection of the gravitational force, and the average station error of many astronomical positions in Canada amounts to about 600 feet However, accuracy of position of even the above order is a tremendous improvement where land features on existing maps may be many miles in error, and this means of control is exceedingly useful for small-scale maps in northern Canada where geodetic control has not yet been laid down.

### Instruments

The surveyor of 1887 generally used the old-fashioned theodolite for cadastral work, although even then the transit was coming into use. On Dominion Lands Surveys of that time both 3-inch and 6-inch transits were in use, the latter instrument reading to 20 seconds of arc. The replacement of the theodolite by the transit on legal survey work was, however, not rapid, and even in recent years surveyors in private practice have continued the use of the original instrument. As would be expected, present-day transits embody radical improvements in design as compared with the types of fifty years ago. Important developments include large telescope apertures with decreases of focal length, internal focussing lenses and increased precision in circle graduation and circle readings. The most noticeable change of all is the smaller, more compact and much lighter instruments, beautifully machined and modelled.

### Linear Measurements

A vital factor in survey practice, fifty years ago, as now, was the linear measurement of distances. The old wire chains, on which the surveyor of fifty years ago relied for his distance measurements, are familiar to everyone. Manufactured in 66 and 100-foot lengths and consisting of 100 links, each chain had 600 or 800 bearing surfaces to wear and gather mud or ice, and 400 or 500 loops which might stretch or open under tension. Variations in measurements were consequently inevitable even apart from lack

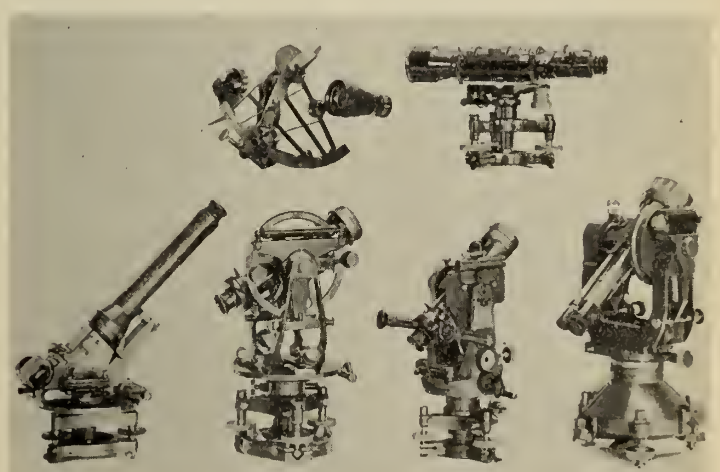

Fig. 5—Modern Surveying Instruments.

of standardization in chain lengths. An interesting example of chainage error in early surveys is provided by the results of the retracement of parts of the Principal Meridian which runs northward a short distance west of Winnipeg. This line was first run in 1871 and was retraced in 1912. The length of each section along this meridian (excepting the road allowances) was supposed to be exactly 80 chains, or one mile. Actually the retracement showed the lengths of the sections to be those given in Table II.

Courtesy of Royal Canadian Air Force.

**Fig. 6—Looking eastward up the Vermillion Pass in the Rocky Mountains, Kootenay National Park. Banff-Windermere Road in the Foreground.**

Table II

Actual Lengths of One-Mile Distances Obtained on Resurvey

| | Tp. 6 Chains | Tp. 9 Chains | Tp. 13 Chains | Tp. 15 Chains |
|---|---|---|---|---|
| Section 1......... | 80.25 | 80.12 | 80.18 | 80.20 |
| Section 12......... | 80.23 | 80.20 | 80.21 | 80.20 |
| Section 13......... | 80.24 | 80.21 | 80.19 | 80.22 |
| Section 24......... | 80.26 | 80.23 | 80.21 | 80.23 |
| Section 25......... | 80.24 | 80.20 | 80.20 | 80.28 |
| Section 36......... | 80.26 | 80.21 | 80.20 | 80.23 |

The chain used in the original survey was a Gunter's 66-foot chain. On the retracement a 300-foot steel tape was used which had been carefully standardized. Considering the conditions under which the original survey was made, the uniformity of the figures in Table II shows that a great amount of care was taken in the actual field measurements; also that the chain must have be n too long by a ratio of approximately 1 in 400, an error which might be compared with the present precision of similar surveys of 1 part in 2,000 to 1 part in 5,000 or better.

Improvement in the mechanics of linear measurement while not enjoying the scope of instrument design and manufacture, has been very noticeable. The development of the steel tape, the standardization of chain and tape lengths, and the use of alloys with a low coefficient of expansion are important factors of progress in the last half century. Corrections for temperature, sag, stretch and slope must, however, still be made.

The first record of steel tapes on surveys in the Dominion was in 1886 when a 66-foot steel band was used on a traverse of the Canadian Pacific Railway through the Rocky Mountains. Today steel tapes varying in length from 66 feet to 500 feet are used entirely. For extremely accurate measurement, such as geodetic base lines, invar tapes or wires are used.

### Hydrographic Survey and Charting

In no branch of surveying is accuracy and reliability put to a more definite test than in the survey and charting of Canada's coastal and inland waterways. With the development of modern navigation, involving greater draught, higher speed and more intense competition, modern accurate charts are a necessity and in constant demand. Improvements in ships and increased sea traffic must be met with improvements in navigation safeguards. Comparatively fast speed in fog and cutting of corners may save for a ship the fuel and other expenses that will turn loss into profit. To carry on this practice safely, there must be absolute reliance on the accuracy of the marine chart. So great has been the progress in charting over the past fifty years that not only is it difficult to cover it briefly, but the methods of 1887 seem primitive and inadequate. The magnetic compass has been replaced by the gyroscopic compass, and the sounding lead by the echo-sounding instrument. In both hydrographic work and navigation the direction of the course is checked and determined with the highly developed radio direction finder.

Of all charting aids, that of the echo-sounding instrument for determining depth is without doubt the greatest and most important innovation. In speed, scope and accuracy the modern method far surpasses the old hand-line and wire sounding devices. A ship equipped with an echo-sounding instrument can follow a charted channel under the worst fog conditions. Canadian hydrographers have been among the first to adopt this method of accurately plotting sea-floor topography. Today all hydrographic steamers are equipped with this modern instrument and many of the launches as well.

While the sea floor is plotted through the mechanics of sound, plotting of the coast line has kept pace through aerial photography. Used in conjunction with triangulation along the coast, topographical features can be accurately plotted in the detail desired and in addition a saving in cost effected. The responsibilities of Canada's Hydrographic and Map Service include not only marine charts, but the collection in the field of the necessary information for the compilation of publications important to navigation interests, such as Sailing Directions and Tide Tables. In addition the Precise Water Levels Division of the Hydrographic Service records and analyses the fluctuations in levels of the Great Lakes and St. Lawrence Waterway System from Port Arthur to Quebec. Probably no branch of surveying more quickly reflects its value in the commercial world than does hydrographic survey work, the accuracy and completeness of which is very definitely reflected in marine insurance rates.

### Aerial Surveying

The limits of this paper do not permit adequate expression of the tremendous advance in topographical and other survey methods made possible by aerial photography. So young is the science, so rapid the developments in planes, cameras and plotting equipment and so great the possibilities of application that any description of present practices can only be regarded as depicting a transition stage. Already ground methods of mapping in Canada, except in mountainous areas, have practically disappeared. Control points are of course still fixed by ground methods.

There is no fair comparison between ground and aerial mapping. Under ground methods only those features a surveyor actually locates by measurement or indicates by sketches can be mapped. The proposed scale of the map governs the number of measurements to be secured and the cost of the work is dependent upon the area to be covered, the character of the country and its accessibility. Even in settled or open country, the wealth of accurate detail that is on call to the surveys engineer from aerial photographs, and the speed with which an area can be covered, gives the advantage to the aerial method.

In Canada vertical photography is used in rough country where a stereoscopic examination of over-lapping photographs enables inequalities of the ground surface to be portrayed. Oblique photography has been found most suited for country of minor relief and where small scale maps will meet requirements.

Control for plotting from aerial photography is taken from geodetic triangulation wherever available. Such control is generally extended by subsidiary triangulation, traverses, cadastral survey data and photo-topographical surveys. On small scale maps plotted from obliques, adequate control is cheaply provided through astronomical observations of latitude and longitude made at intervals of from 50 to 75 miles.

Many instruments have been developed to facilitate plotting and contouring from aerial photographs, some of which are complicated and expensive. Less elaborate machines, suitable to Canadian conditions are now being developed, some of them in Canada.

Aerial surveying is naturally a field undreamed of by the surveyor of fifty years ago. The production of the topographic map is only one of its uses. The photographs themselves are a veritable mine of information and one trained in their interpretation can extract valuable and definite information relative to geology, forestry, highway, railway and transmission line location, flood control, water power, irrigation and other fields too numerous to mention. These multiple uses of aerial photographs provide an entirely new field of basic information for design and cost analysis. The extensive information available has already effected startling savings. In one recent case a map plotted from aerial surveys showed a possible reduction in the length of a projected road which saved, in construction costs, an expenditure equivalent to a substantial part of the cost of aerial photography for a whole season. Such possibilities must be kept in mind when the cost of mapping from aerial photographs is under consideration. Estimates of mapping cost naturally vary but the figure most commonly used in Canada is about $6.00 per square mile for uncontoured maps, excluding any other uses for the photographs. Contracts at $7.50 per square mile for flying only were made in 1936. Recent United States figures for aerial photographs vary from $3.00 to $18.00 per square mile, depending on the scale and the size of the area to be covered.

To what extent these figures will be changed by the rapid development of aerial surveying no one can accurately foretell. Almost within the last year the nine lens camera, covering some 550 square miles in one exposure, has been developed. Automatic taking of photographs with timing set to provide any desired overlap and the subsidiary camera to automatically record time, temperature, altitude, tilt, etc., are already accomplished facts.

### Geodetic Surveys and Control

Accurate horizontal and vertical control are vital factors in the survey of a large country. Detail surveys of small areas are naturally made with a degree of precision suitable only to local requirements, but the accumulation of errors when extended to large areas produces compilation anomalies and difficulties of major importance. Such has been Canada's experience, and the Geodetic Service was established to provide a national network of permanently marked points whose accurate relative positions (altitude, longitude and elevation) are determined. By this means the accuracy of other surveys by government or private organizations can be checked, their errors segragated, and the results of disconnected and frequently conflicting surveys co-ordinated.

Continuous geodetic surveys have not yet been extended much beyond the limits of the area served by railways, so that in northern Canada control for mapping

Fig. 7—Survey Party using Scow Transport down Peace River, 1916.

and charting operations is based on astronomic positions and, for altitude, on local level datums.

For geodetic surveys, triangulation methods are generally employed. Stations are placed on the highest hills, and are, in work of greatest precision, preferably spaced at approximately 25-mile intervals. Distances as great as 150 miles between stations are occasionally necessary in Canadian practice, such as those spanning Cabot Strait between Cape Breton island and Newfoundland, across the Gulf of St. Lawrence west of Anticosti island, across Lake Superior and between Queen Charlotte islands and the British Columbia mainland.

The angles of primary triangulation are measured at night when air conditions are more conducive to accuracy,

Fig. 8—Loading Surveyor's Equipment for Transport by Air. Fort Smith, N.W.T., 1936.

sights being made on electric signal lamps operated by dry cells.

The high accuracy of the primary triangulation nets is not required for most purposes of control. Consequently, secondary nets adequately serve local purposes and are much in demand for topographic, hydrographic and other requirements. In this class of triangulation work, stations are spaced at intervals of 5 to 15 miles and sights are made in daylight by cotton signals. Positions of latitude and longitude are calculated on the North American Datum established in Kansas, to which all geodetic work in Canada, the United States and Mexico is referred.

No important change in standards of accuracy has occurred in geodetic practice in the last half century, although remarkable improvements in methods have taken place. Electric signal lamps of increased power and penetration have displaced kerosene and acetylene lamps. The aeroplane has been used in the selection of sites for triangulation stations with remarkable success. The introduction of invar tapes has greatly reduced the cost of base lines and the heavy instruments of the past have been replaced by smaller, lighter and more quickly operated theodolites.

The Canadian precise level system is based on Mean Sea Level as determined at three tidal stations on the Atlantic and two on the Pacific established by the Hydrographic Service. When the first transcontinental line of levels was completed in 1916, the discrepancy between Atlantic and Pacific amounted to only six-tenths of a foot.

There has been little or no change in the standards of levelling accuracy since the beginning of the century.

The importance of permanent bench marks is now more fully appreciated and the supporting structures are very carefully chosen. These consist of building foundations, bridge abutments, bed rock, or especially built concrete piers. In large towns and cities, bench mark piers of great permanence are established at selected sites.

### Transport and Communication

The exploratory engineer or surveyor usually precedes settlement and as a consequence has been largely dependent upon the more primitive forms of transport. Until a very few years ago the transport and maintenance of a survey party in our Canadian hinterland was a greater problem than the carrying on of the survey itself. In common with his predecessor of 1887, the surveyor of a few years ago relied upon the man, the horse and the dog for motive power, using such overland equipment as carts, wagons, sleighs and toboggans. The pack train was common, as well as the earliest form of transport, namely back-packing. Canada's numerous and far-reaching waterways gave, in many cases, the sometimes fortunate alternative of the river boat, canoe, scow or raft. Base line surveyors easily recall the year-long field expeditions which, coupled with almost absolute lack of communication, entailed nearly as much planning and forethought as the Arctic expedition of the present day. Nearly every surveyor remembers his dependence upon the head-packer and the relief felt when the pack-train returned on schedule with its supplies from the frontier town, where perhaps the arrival of the pack-train had coincided with a local celebration.

But science and modern methods have revolutionized survey transport. The automobile and tractor, the outboard motor and most wonderful of all, the aeroplane, have largely relegated the problem of transport to the background. Journeys that formerly required weeks or months of travel are now accomplished in a few hours. Canada's northland, so recently remote, vague and inaccessible, has been brought through the agencies of aerial flight and water almost to the back door of her towns and cities. Air transport of animals, supplies, and equipment and machinery of all kinds is now commonplace.

Radio transmitting and receiving sets ensure instantaneous communication and coupled with aeroplane service, save time and money, rectify mistakes and reduce personal hazard. In the past winter between December and March a survey party completed a 115-mile north-easterly extension of the Ontario-Manitoba boundary line. An aeroplane took in personnel and equipment, moved camp when requested through radio communication, brought in further supplies at the same time, and brought out personnel and equipment when the winter's programme was completed; a modern accomplishment that could not be visualized fifty years ago.

In conclusion it can be said that Canada's progress in surveying and mapping has, through the past half century, kept pace with her needs. With her increasing development will go an increasing need for additional surveys, maps and charts. Even with the much older development of European countries, it is recognized that the mapping of their comparatively small areas will never be wholly completed. Canada is a huge country with great natural resources that depend for development on transport by air, land and water. In mapping the tremendous areas covered by these resources and in mapping and charting their routes of travel, Canadian surveyors seem to have an almost unlimited field of service.

# The Development of Aviation

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THE PRE-WAR PERIOD

A century before the foundation of the Canadian Society of Civil Engineers, the Montgolfier brothers made the first balloon ascents in France. During the nineteenth century Lilienthal in Germany, Pilcher in England and Chanute in the United States experimented with gliders. These activities in lighter- and heavier-than-aircraft were the foundation on which was built our modern aviation.

Canada took little part in this work. Though no doubt occasional balloon ascents were made, the only record of the design and construction of an original flying machine in Canada during the nineteenth century, which can be traced, is that of Mr. Charles Pagé, of Montreal. His invention was a dirigible, cigar shaped balloon, from which was suspended a nacelle. Descriptions of the machine and the method of operation were published in two articles in the Montreal Witness on May 14th and June 18th, 1879.

A trial flight was made on June 21st, 1879, using an ordinary spherical balloon. No hydrogen was available and city gas had to be used, which made it necessary to discard part of the propelling machinery to lighten the load. The ascent was made from the Shamrock Lacrosse grounds in Westmount. An exciting landing not without risk in the darkness, was made 45 miles away near Ste. Hyacinthe. The flight led to no practical result, but showed that even in those days Canadians were not insensible to the importance of aviation.

As the new century dawned, experiments in both Europe and North America intensified. Mr. W. R. Turnbull was the father of aeronautical research in Canada. In 1902 he constructed the first Canadian wind tunnel, at Rothesay, New Brunswick, and commenced the research work which established him as the Canadian pioneer in this field and later brought him into prominence in the science of aeronautics. His wind tunnel was powered by a heavy four-bladed fan-propeller driven by an electric motor. The fan was mounted at one end of a rectangular box 6 feet long and 22 inches square, and pushed the air through this "tunnel" at about 10 miles per hour. Thin baffle plates were employed to take out the propeller swirl from the air stream.

In 1907 he published the first Canadian Aeronautical Research paper in the Physical Review, entitled "Researches on the Forms and Stability of Aeroplanes." The term "aeroplanes" was used at that date to designate what are called aerofoils. This paper described experiments in which the lift, drag and centre of pressure movement were measured for aerofoils of zero camber, positive and negative camber and reflex camber.

Turnbull discovered the laws of the centre of pressure movement on aerofoils and made deductions from these laws which explained the longitudinal stability of aeroplanes. He showed in particular how the aerofoil with reflexed trailing edge had automatic stability while the conventional single curvature aerofoil had unstable characteristics due to the movement of the centre of pressure with change in angle of incidence.

He published a paper entitled "Efficiency of Aeroplanes" in the Aeronautical Journal for July, 1908, and in October, 1908, in "Aeronautics" a report on French motors, made at Dr. Graham Bell's request for the Aerial Experiment Association.

Turnbull constructed an experimental track for testing air propellers in the open, and in April, 1909, he published a paper in the Scientific American Supplement on the "Efficiency of Aerial Propellers" and in the Aeronautical Journal for October, 1910, and January, 1911, two more on the "Laws of Airscrews." For these papers Turnbull was presented with the bronze medal of the Royal Aeronautical Society. He showed that the efficiency of airscrews varies with the forward speed, attaining a maximum value depending on the percentage of apparent slip. The thrust r.p.m. brake horsepower and axial speed of the propellers on test were measured and he estimated that a limit of 80 per cent efficiency was indicated, a figure not much exceeded in modern design.

Perhaps Turnbull's greatest contribution to aviation was his controllable pitch propeller. His work on this subject dates from 1918; at that time the possible need for a controllable pitch propeller was so remote that tribute must be paid to his far-sighted vision.

His ideas on controllable pitch were strongly backed by the Associate Air Research Committee of the National Research Council and a grant for their development was made. A full-size propeller was constructed by Canadian Vickers and tests were carried out at Camp Borden. The results were encouraging and demonstrated the feasibility of controlling pitch, though the advantage of controllable pitch propellers could not be demonstrated with the aircraft used in the tests, owing to its small speed range. The American rights to the Turnbull controllable pitch propeller are owned by the Curtiss-Wright Company and his fundamental ideas are embodied in the controllable propeller now in common use.

In 1900 the Wright Brothers began their work at Kitty Hawk, North Carolina, which led to the first power driven flight on December 7th, 1903. Samuel Langley, of the Smithsonian Institution, working on similar lines, had built a man-carrying aeroplane which he tried without success on the Potomac river in the same year. The veteran inventor of the telephone, Dr. Graham Bell, a Regent of the Smithsonian Institution and an intimate friend of Langley, had for some years been experimenting

**Fig. 1—First Military Aircraft Trials, Petawawa, Ont. August 1909.**

with kites and airscrews in his private laboratory at his summer home near Baddeck, Cape Breton Island. Mr. J. A. D. McCurdy, a local boy, had played as a child in the laboratory and as he grew older had helped Dr. Bell in his work. In 1907 he graduated from the School of Practical Science at Toronto University and returned to Baddeck, taking with him another graduate, F. W. Baldwin, of the same school. Both were enthusiastic believers in the future of flying.

During the summer of 1907, Dr. Bell saw that if his aeronautical experiments were to serve any practical end, he must have the help of a trained engineering staff. He naturally turned to McCurdy and Baldwin. On October 1st of that year, he formed the "Aerial Experiment Association," with the objective of constructing "a practical aerodrome or flying machine driven through the air by its own power and carrying a man." The five members of this Association were Dr. Bell, Messrs. McCurdy, Baldwin, Glen Curtiss and Lieutenant Selfridge. Glen Curtiss was then building motor-cycle engines in a small factory at Hammondsport, New York, and his assistance was sought on account of his special experience in the construction of light power plants, as it was realized that without a suitable power plant little progress could be made. Lieutenant Selfridge was granted leave from the United States army to participate in the work of the Association. Mrs. Bell, always keenly interested in her husband's scientific work and confident that the Association would produce practical results, supplied the working capital—$35,000. The full story of the Association is recorded in a series of bulletins, of which five were typewritten, one for each member. Two copies of these bulletins still exist, one in the Smithsonian Institution, and the other, given by Mr. McCurdy, in the aeronautical museum of the National Research Council in Ottawa.

During the summer of 1907, Dr. Bell designed and built in his laboratory at Baddeck a large tetrahedral kite known as the "Cygnet." It was ready for trials late in the year and on December 6th it was successfully flown with Lieutenant Selfridge as passenger from the surface of the Bras d'Or Lakes, the motive power being supplied by a steam tug. It rose to a height of 170 feet and made the first recorded flight carrying a passenger of any heavier-than-aircraft in Canada.

The Association decided that each member should design a flying machine on his own ideas. Dr. Bell continued his kite experiments in the hope that he would get one to fly under its own power, while the four other members built gliders equipped with a motor, following the example of Langley, the Wright Brothers and contemporary European experimenters.

The work of the Association was continued during the winter at the Glen Curtiss factory at Hammondsport, New York. On March 12th, 1908, the first aeroplane was completed and was successfully flown from the ice at Lake Keuka, New York. The machine had been provided with skis and glided over the ice for a hundred feet or more before it rose and then flew steadily at an elevation of ten to twelve feet above the ice, carrying Mr. F. W. Baldwin as pilot. This was the first flight by a British subject. The "Red Wing," designed by Baldwin and built in the Glen Curtiss factory was ready for flight with an engine which Curtiss had specially designed for it. On May 18th, it was successfully flown. Later in the summer Curtiss' "June Bug," the third of the Association's aircraft, was ready for flight. He entered it in a competition announced by the "Scientific American" for a trophy for the first heavier-than-air machine to fly one kilometer. Many machines were entered, but few were successful in flying the required distance, and the "June Bug" was awarded the trophy.

McCurdy's "Silver Dart" was completed in November and assembled at the Bell laboratory in Baddeck for trials from the ice there. On February 23rd, 1909, Dr. Bell was able to cable to the London "Times" in part as follows:—

> "First flight of a flying machine in Canada occurred here today when Mr. Douglas McCurdy, native of Baddeck, Nova Scotia, flew a distance of about one-half mile at an elevation of about thirty feet above the ice on Baddeck Bay in an aerodrome of his own design, named the 'Silver Dart'."

The following day a flight of four and a half miles at a speed of 40 miles an hour was made in a circle round Baddeck Bay. On March 8th a distance of eight miles was covered in the fast time of eleven minutes and fifteen seconds.

Aviation history was made rapidly in the little town of Baddeck that winter. The "Silver Dart" was without doubt an advance on any aircraft previously flown. It embodied several new and very important features, notably a three-wheel undercarriage, tapered wings and the use of aileron control.*

Dr. Bell then felt that the purpose for which the Association had been formed had been accomplished. Lieutenant Selfridge had been killed while flying with the Wright Brothers near Washington, and he was anxious that the three remaining members should all be free to take advantage of the results of their work in the Asssociation. It was accordingly dissolved on March 31st, 1909.

The Association's life was short but brilliant. No contemporary work was more successful or productive of lasting results and Canadians are beginning, after a generation has passed, to recognize the contribution made to aeronautics by this little band of workers in far off Cape Breton Island. Dr. Bell has, of course, long passed to his rest, full of honours and world-wide renown. Two of the members are, happily, still with us—Messrs. McCurdy and Baldwin—and still actively interested in aviation.

Messrs. McCurdy and Baldwin continued their activity in Canada and endeavoured to interest the Department of Militia in their work. Lieutenant Colonel G. S. Maunsell, M.E.I.C., then Director of Engineer Services at militia headquarters, had followed with interest the early development of aeronautics and had contributed two papers on the subject to meetings of the Ottawa Branch of the Engineering Institute. He strongly backed their efforts and approval was finally given for trial flights to be conducted at Petawawa in August, 1909. Unfortunately, the available landing areas there had a very different surface from that of the smooth ice at Baddeck. Had a good aerodrome been available, the trials might have had a very different result. As it was the frail aircraft could not stand the rough landings and after a series of early morning successful trial flights, both aircraft crashed on landing, fortunately without injury to their pilots. The military authorities remained unconvinced of the practical value of aircraft in military work and refused further assistance.

It is unfortunate that the Militia Department refused to take cognizance of McCurdy's and Baldwin's two hundred successful flights made under proper conditions and adopted a conservative attitude, based on the reports of the trials made from rough ground at Petawawa. Their lack of vision had an influence detrimental to the development of Canadian aviation.

Nineteen hundred and ten saw a renewal of aviation activity and the holding of the first flying meet at Montreal. The famous young French pilot, Jacques de Lesseps, brought his Bleriot monoplane to Canada and made flights at Montreal and Toronto in July.

The first aeroplane built and flown in western Canada was a 35-40 hp. Anzani engine biplane constructed in 1910 out of Sitka spruce and ash, with silk covered wings, from their own designs by William Templeton, William McMullen and Winston Templeton, of Vancouver. This

*A full description of the aircraft will be found in the January, 1937, issue of "Canadian Aviation."

home-made aeroplane, after many weeks of trials, finally made a few successful, though short flights from the race track on Lulu Island, B.C.

McCurdy's next activity was his flight from Key West, Florida, to Havana, on January 30th, 1911. This was the longest overseas flight made up to that date, It was made at a speed of fifty miles an hour, at an elevation of about one thousand feet, in a plane of his own design. He was forced down short of fuel within sight of the crowds waiting his arrival on the shore and was picked up by a

Courtesy of Royal Canadian Air Force.

**Fig. 2—Royal Canadian Air Force Camp and Aerodrome, Camp Borden, Ont.**

destroyer following him. For this flight, McCurdy was awarded a prize of $8,000 and was given a tremendous welcome in Cuba. Fortunately, the plane was undamaged and the next day he made several successful flights from an aerodrome which had been prepared near Havana.

Air meets were held in Toronto and Hamilton in August, 1911, and many successful flights were made, including a race between Charles F. Willard, a United States pilot, and Mr. McCurdy, from Hamilton to Toronto, which was won by the latter in the fast time of thirty-six minutes for thirty-five miles. There was then a lull in activity until the spring of 1914, when flying was again resumed in Toronto and Hamilton.

Improvement in the strength, reliability and efficiency of aircraft was rapid between 1908 and 1914. Each new model built showed advances in reliability, speed, carrying capacity and manoeuvrability. The progress made in these years is best exemplified by the fact that an attempt to fly the Atlantic from Newfoundland to Ireland was being organized by Lieutenant-Commander John Porte, R.N., in August, 1914, when the outbreak of war abruptly changed the whole course of aviation.

### THE GREAT WAR, 1914—1918

The record of Canadians in the air was remarkable. It was, however, due to the efforts of individual Canadian officers and men serving in the British air services. Even the training organization in Canada, which grew to large proportions in 1917 and 1918, was under British direction.

None of the allied powers had realized in advance the important part aircraft would play in the world war and at first all were reluctant to divert men and material to the air arm. The British services were only able to muster a score of aeroplanes to accompany the British Expeditionary Force to France in 1914 and the other armies were no better prepared. Experience soon showed the value of aircraft. Observation was at first the only use. Soon the rival observers took to fighting in the air, and aircraft were armed with machine guns. As their power and speed increased, bombing was added. Special recruitment, both of pilots and mechanics, soon became necessary as the air services expanded rapidly and the casualties in the air were heavy. An increasing stream of transfers from the Canadian Expeditionary Force to both the Royal Naval Air Service and the Royal Flying Corps commenced. In addition, both services readily accepted young Canadians who had learned to fly in private schools.

#### The Curtiss School

The Curtiss Flying School in Toronto was established in the spring of 1915, with J. A. D. McCurdy in charge, to meet this demand. The following description by one of the first dozen pupils gives a picture of conditions at that time:—

> About the 1st of May 1915, a news item appeared in the Victoria papers to the effect that the Royal Navy needed air pilots and if any Canadians of good family, preferably with engineering training and who were physically fit, would learn to fly at their own expense and would pay their way over to England, they would be taken on strength as Chief Petty Officers, and if they served for so long as their services were required, their way would be paid back to Canada and they would be granted a gratuity of £150.
>
> On the strength of this news item, I reported to the Senior Naval Officer at Esquimalt and was accepted as the first candidate from the west on the 6th of May, 1915.
>
> The Curtiss school was then giving a course in flying on Curtiss flying boats in the Toronto Bay, with hangars at Hanlan's Point, with the promise of landplane training at a later date at Long Branch. The fee was $400 for 400 minutes with a rebate at the rate of a dollar a minute if for any reason the course was given up.
>
> J. A. D. McCurdy was in charge of the school, but did no active flying himself.
>
> We did not go solo on the flying boats, but when in the opinion of our instructor, we were capable of handling them, we were transferred to the landplane school which had then opened at Long Branch. Once again we did not go solo until it came time to take our tests, our first solo flying time being our official test.
>
> Taken all round I considered it was a well run flying school and that we got excellent value for our money.
>
> During our days at Long Branch the Royal Flying Corps sent representatives to Canada and offered us commissions as Second Lieutenants if we completed our course. Most of us, however, stayed with the R.N.A.S. who, in turn, raised the ante by making us "Flight Sub-Lieutenants, R.N., probationary, temporary"! They also paid for our passage to England but did not refund any of the cost of learning to fly.

Through this school, nearly seven hundred young Canadians were accepted in Canada for the Royal Naval Air Service and proceeded overseas, the candidates being examined and tested by the Royal Canadian Navy. Many others joined the Royal Flying Corps but no exact record is apparently available.

#### The Royal Flying Corps in Canada

The intense air activity in the latter half of 1916 during the battle of the Somme was the principal factor which led to the establishment of Royal Flying Corps recruiting and training units in Canada. The exploits of Canadian pilots soon drew attention to their natural ability in air warfare. After negotiations between the representatives of the Canadian and British Governments, authority was given in December, 1916, for the establishment in Canada of Royal Flying Corps training units. The Imperial Munitions Board added an Aviation Branch under Mr. G. A. Morrow to their many activities, and, with the consent, approval and assistance of the Canadian Government, the training units and the necessary recruiting agencies, technical services for the preparation of aerodromes, the construction of quarters and other accommodation and the purchase of supplies were rapidly organized.

In January, 1917, the nucleus of a Royal Flying Corps training and administrative section arrived in Canada. Camp Borden, hitherto used as an infantry training camp for the C.E.F., was placed at their disposal by the Government and a contract was immediately let for the construction of fifteen hangars, barrack buildings, water supply, and all the requirements for a flying training unit. At the same time, the military property at Long Branch, west of Toronto, was taken over and there was formed the first flying unit of the Royal Flying Corps in Canada.

Sites for additional training camps were later selected at Leaside, Armour Heights, Mohawk and Beamsville, and a ground school opened at Toronto University. Wholehearted co-operation was given in all this work by the Canadian Government, who assisted the organization in every way and provided the funds through advances by the Finance Department to the Imperial Munitions Board.

Space will not permit any detailed account of the training activities of the Royal Flying Corps in Canada, nor a discussion of the many engineering problems involved in the construction, equipment and maintenance of the bases and shops.*

The organization ceased its work at the armistice in November, 1918, and was disbanded. Its record is as follows:—

| | |
|---|---|
| Pilots trained and sent overseas | 2,539 |
| Pilots trained and ready, waiting to go overseas at the armistice | 240 |
| Pilots retained in Canada as Instructors. | 321 |
| Pilots trained for United States Air Services | 370 |
| Pilots partially trained at armistice | 587 |
| Cadets in ground training courses at armistice | 3,500 |

### Canadian Aeroplanes, Ltd.

Canadian Aeroplanes, Ltd., was organized in December, 1916, by the Imperial Munitions Board under the presidency of Sir Frank Baillie to build the aircraft for the Canadian training units. A large number of aeroplanes and spare parts were also supplied for the training services in the United States. In the twenty-one months of its existence it built 2,900 aeroplanes, valued at $14,000,000. It took over from the Curtiss Flying Service a small factory but in April, 1917, the need for expansion forced the acquirement of larger premises on Dufferin Street, Toronto.

Their shops covered some six acres of floor space, and were built in two and a half months. The aircraft adopted for training in the Royal Flying Corps in Canada was the Canadian J.N.4, or Curtiss "Jenny." Supplies of materials for this new industry had also to be organized, including the cotton cloth for the covering of the wings (the Irish linen hitherto used was unobtainable), silver spruce, not only for Canadian requirements, but for those of all the allied powers (this item alone involved an extensive organization in British Columbia), ash for the longerons and white oak for the building of propellers.

In addition to the 2,900 "J.N.4" aircraft, Canadian Aeroplanes built 30 "F.5" twin engined flying boats for the United States Naval Service during 1918. This was the largest type of flying boat then in existence. Mass production of the "Avro" trainer was just beginning when the armistice closed this chapter of aeronautical activity in Canada.

The combined expenditure by the Imperial Munitions Board on the training organization and Canadian Aeroplanes Limited, to December 31st, 1918, was approximately $40,000,000.

### The Royal Canadian Naval Air Service

Submarine warfare on the North Atlantic forced consideration of plans for the protection of the constant stream of supplies passing overseas from North America to the United Kingdom and French ports. Late in 1917, the convoy system was instituted and immediately the marine casualty rates fell.

The visits to Atlantic coast waters of long range U boats early in 1918 (an oil tanker was torpedoed and sunk within ten miles of Halifax harbour on one occasion) made air patrols necessary at Halifax and Sydney for the protection of the convoys which gathered there.

Two years earlier the Admiralty had advised the Canadian Government of the conditions which might result from the extension of submarine warfare and suggested that Canada should organize a Naval Air Service. Two flying boats were shipped to Halifax in 1916 but no action was taken in the matter till March, 1918, when the Admiralty again raised the question and the Canadian Government agreed to organize the Royal Canadian Naval Air Service, for which suitable bases were located at Dartmouth and Sydney.

As the United States were sending large numbers of their troops overseas through Canadian ports they were desirous of having aerial patrol protection for the troopships. The Canadian and United States Governments combined efforts to put the Canadian air bases into commission until such time as Canadians could be trained to carry out the air patrols. Under this arrangement, the United States Government supplied the following for the unit established at Halifax:—

Courtesy of Royal Canadian Air Force.

Fig. 3—Royal Canadian Naval Air Service Base, Dartmouth, N.S. 1918.

(1) Twelve "H.S.2 1" flying boats complete with all necessary spares.
(2) Two kite balloons, complete, with necessary additional spares, winches for same, and hydrogen plant.
(3) Steel portable hangars for housing flying boats.
(4) Complete U.S. Navy personnel for the base.

*See "Aviation in Canada, 1917-18" by Allan Sullivan.

Similar arrangements were made for the North Sydney base, as it was believed that the enemy submarines would choose the St. Lawrence route for operation in September and October.

On August 16th, 1918, the American advance party, with two flying boats, arrived at Halifax. The personnel were, pending completion of their buildings, put under canvas, the machines were assembled and on August 25th, 1918, the first convoy patrol was carried out. Regular patrols and convoy flights were flown from both stations, until the signing of the armistice.

On September 5th, 1918, the general outlines of regulations governing the Royal Canadian Naval Air Service were approved by the Canadian Government. The recruitment and training of personnel and equipment of the stations with Canadian aircraft was provided for.

Up to the time of the armistice, eighty-two cadets had been recruited; sixty were under training in the United States, nineteen were in England training for service in the "Lighter-than-Air" section.

Immediately after the signing of the armistice, the Department of Public Works was instructed to stop construction at both bases. Store houses, hangars, sleeping and recreation buildings had, by that time, been completed at both Dartmouth and Sydney. The Dartmouth base is still in use by the Royal Canadian Air Force and is today being modernized and enlarged.

The R.C.N.A.S. was demobilized after the armistice. All flying material, including 24 "H.S.2.L." flying boats and 25 Liberty motors, was presented by the United States to Canada. These flying boats later proved invaluable and were the foundation on which was built the forest patrol systems organized in the succeeding years.

## POST-WAR PERIOD

Canada was in an excellent position after the armistice to deal with aviation intelligently. The statutes contained no reference whatever to aeronautics and the war organizations at home and overseas had been disbanded. Freedom of action was complete.

There was little recognition on the part of the public generally that flying would soon become as important in peace as it had been in war, but men of vision had been watching with increasing interest the conquest of the air. As early as the fall of 1915, Dr. Charles Camsell, M.E.I.C., Past President of The Institute and now Deputy Minister of Mines and Resources, had made inquiries about obtaining flying boats for use in northern Canada to ease the burden and increase the efficiency of scientific parties working in the remoter parts of the Dominion. Concentration of every effort on "winning the war" prohibited any progress on these lines before the armistice.

Canada was fortunate in having, not only a great fund of energy and enthusiasm for aviation in the thousands of young Canadians who made such a brilliant record in the air services, but a virgin field for the useful and economic employment of air services in the exploration and development of the northern areas, where there were no roads or railways, where travel was a slow and arduous business and where better means of access and observation were the key to development.

Within a few days of the armistice a meeting was held in Ottawa under the auspices of the Dominion Land Surveyors' Association to discuss the future of aircraft in such work. Surveyors, foresters and geologists eagerly lent their knowledge to planning these new developments with the airmen. Enthusiastic young men were returning from overseas and demanding that their opportunities for flying should be continued and extended. Surplus aircraft and war disposal stock were coming on the market and available at low prices, necessitating action to control flying in Canada. Canadian representatives at the Peace Conference were assisting to draft the International Convention for Air Navigation to determine the principles underlying the regulation of civil aviation in all parts of the world. In March, 1919, the Canadian Pacific Railway asked Parliament for an extension of their powers to include the operation of aircraft. This brought the matter directly to the Government's attention. To meet the situation, the Air Board Act was introduced, passed rapidly through all its stages and received Royal Assent on June 6th, 1919.

By the Air Board Act a Board on Aeronautics was established which had broad powers of control over all forms of aeronautics. Doubts were expressed as to the jurisdiction of the Dominion, and this question was not finally settled till 1931 when the Privy Council decided that aeronautics lay wholly within Federal jurisdiction.

The Air Board Act provided in detail for the regulation of civil aeronautics and it was framed primarily for this purpose. Powers to deal with military aeronautics were less well defined and were then regarded as temporary pending the post-war re-organization of the defence forces, which appeared inevitable.

### The Air Board 1919-1922

The first Air Board was appointed by an Order-in-Council dated June 23rd, 1919. The Honourable A. L. Sifton was chairman, Colonel O. M. Biggar, who had acted for Canada on the sub-committee of the Peace Conference in Paris dealing with Air Conventions, Vice-Chairman, the Honourable S. C. Mewburn, Minister of Militia and Defence, the Honourable C. C. Ballantyne, Minister of the Naval Service, together with the Deputy Postmaster General, the Chief Inspector of the Department of Customs and Inland Revenue, and the author were the other members.

No time was lost in organizing the necessary staff for the duties imposed by the new Act. Four civil branches were created:—

- (*a*) Secretary's Branch, dealing with organization, finance, staff and departmental duties generally.
- (*b*) Certificates Branch, dealing with the licensing of aircraft and personnel.
- (*c*) Flying Operations Branch, to conduct any flying operations required for other Government Services.
- (*d*) Technical Branch.

Before the close of 1919 the preliminary organization was completed. Air Regulations based on the International Convention for Air Navigation governing civil flying in Canada had been approved by Order-in-Council. An Aerial Survey Committee was appointed, representative of the survey services of the Government. Its Chairman was the late Dr. E. Deville, Surveyor General. Dr. Deville, as a young man, had taken the lead in the development of photo-topography. In his old age he had the satisfaction of introducing new methods of surveying from aerial photographs, widely used, not only in Canada but in many other countries.

A survey had been made to ascertain "what public services could be more efficiently, and, in the broader sense, more economically performed by air than by existing methods." Provision had been made for scientific research in aeronautics by the formation, under the Council for Scientific and Industrial Research, of an Associate Air Research Committee. Arrangements had been completed with the Dominion Meteorological Service, looking towards the necessary extension of the existing meteorological services to serve the requirements of aviation, and with the Government Radio Telegraph Service of the Department of Naval Service for co-operation in the development of any radio services required for air navigation.

The Board also took over from the Department of Naval Service the seaplane stations erected during the war at Halifax and Sydney, and from the Department of Militia and Defence that portion of Camp Borden which had been developed as a flying training base by the Royal Air Force.

The Imperial Government generously gave from their surplus war stock, eighty aeroplanes, fourteen flying boats, twelve airships, six kite balloons and much miscellaneous equipment of inestimable value in enabling the Air Board to start its work. In addition, sixteen aircraft were received from the Air Ministry to replace those presented from time to time during the war to Canadian forces and used by the Royal Flying Corps. The flying boats and Liberty motors left at Halifax and Sydney by the United States Naval Air Service were available and the new organization was, therefore, well provided with equipment.

When the preliminary work of organization had been completed towards the close of 1919, the original Board resigned and a new Board was formed, with the Minister of Militia and Defence as Chairman. Colonel O. M. Biggar remained as Vice-Chairman. The Controller of Civil Aviation and Director of Flying Operations were appointed members of the Board, together with the Director of the Naval Service, the Surveyor General and the Inspector General of the Canadian Air Force.

The formation of a Canadian Air Force under the Aeronautics Act was approved on February 18th, 1920. The Service authorized was on a wholly temporary basis. No permanent officers or men were appointed. Its immediate duty was the provision of refresher training for officers and men who had served during the war pending action on the constitution of a permanent Air Force. These refresher courses were established at Camp Borden in July, 1920, and were maintained in active operation until the close of 1922.

Previous to the appointment of the first Air Board, Ellwood Wilson, M.E.I.C., Chief Forester of the Laurentide Company at Grand'Mère, applied to the Department of Naval Service for two flying boats to make trials of aircraft in forest protection and forest survey work. The loan was granted. The two flying boats were flown from Halifax to Lac à la Tortue, P.Q., by Stuart Graham and successful flights were made in August and September. These were followed with general interest by the Dominion and Provincial Forest Services.

The results of these experiments, combined with those of the Air Board surveys, led to the conclusion that the needs of the forest service for improved methods of transportation, observation and travel were of immediate importance.

An Interdepartmental Conference, convened in January, 1920, for the consideration of proposals for the institution of air services, recommended the establishment of air bases at Vancouver, B.C.; Morley, Alberta; Ottawa, Ontario; and Roberval, P.Q., for co-operation with the forest services—Provincial and Dominion. The provincial governments co-operated wholeheartedly. British Columbia supplied a site for a suitable seaplane base at English Bay, and volunteered to defray a substantial part of the cost of the operation. The base at Morley was established for the purpose of better fire protection in the Dominion Government forest reserve on the eastern slopes of the Rocky Mountains. (This station was later moved to a better site at High River.) The operation at Roberval was undertaken at the request of the province of Quebec to provide forest fire patrols, forest surveys, and to facilitate the exploration of forest areas surrounding Lake St. John. The buildings and slipway required were erected by the provincial government. These bases provided facilities for flying operations, not only for the forest services, but for much other government work in these areas.

Consideration was also given at that time, in conjunction with the officers of the Postal Service, to the establishment of air mails. In most countries, inter-city services were the only outlets for aviation after the war. Such services required heavy subsidies from the governments concerned, as in most cases they were not (and still are not) self-sustaining. It was decided that the carriage of mail by air in Canada could well await further development. Until public opinion was riper and experience had been gained in other countries, the operation of such services would be costly and premature. It was not, in fact, until 1927 that inter-city air mails again received active consideration.

In January 1921, a second Interdepartmental Conference on air operations was held in Ottawa to consider the results of the previous year's work and make recommendations as to future progress. The experience of the past year had been so satisfactory that greatly increased demands were received. New bases were established in Manitoba for the patrol and survey of the forest areas surrounding Lakes Winnipeg and Winnipegosis, in conjunction with the Dominion Forest Service, and also at Sioux Lookout, Ontario, with the help of the Provincial Forest Service of Ontario, for similar work in northern Ontario. In 1922 this work was continued on a larger scale at all bases and further new operations were commenced.

The discovery of crude oil at Fort Norman, N.W.T., late in the fall of 1921, led to the first large-scale attempt to establish long range air transport in the Far North. The Imperial Oil Company purchased two all-metal Junkers planes with the object of establishing more efficient communication to the new oil field from Edmonton. The story of this pioneer effort is an epitome of the difficulties to be overcome. Intense cold, Arctic blizzards, rough landings in unknown country, inadequate supplies and unsuitable equipment, all were mastered by hard work and indomitable perseverance. (A new propeller was built on one occasion at a Hudson's Bay post from oak sleigh boards and glue made on the spot from moose hide!)

The results of these first three years' of trial and experimental work proved that aircraft could play a most important part in transportation in the outlying districts of Canada; in forest patrol and exploration; in aerial surveys, by photography and sketching; and other similar work. The use of air transport in the North had, in fact become firmly established.

The question of training a new generation of pilots to take the place of those who had served during the war first received consideration during the year. It was decided that the best personnel for the Canadian Air Force could be drawn from the engineering and science schools of the Canadian universities. Under this scheme a selection was made each year of a number of students in the first year of their course in science or engineering who would, during their summer vacations for three or four years, go to Camp Borden and undergo a thorough training in aeronautics in all its phases. A selected number would be granted commissions in the Air Force on graduation.

One further activity in 1922 calls for mention. The most direct routes between North America and Europe and Asia all pass through northern Canada. As these might become of international importance, it was considered that no time should be lost in making a preliminary investigation of flying conditions in the Arctic. R. A. Logan, a highly qualified pilot who was a Dominion Land Surveyor and had long experience of travel and conditions in the North was selected to make this reconnaissance and accompanied the supply and relief ship on her annual visit to posts in the Arctic Islands. Much valuable information was obtained, but it was not possible, under the re-organization of the Air Services which followed, to continue this investigation.

### Department of National Defence

On January 1st, 1923, the Act creating the Department of National Defence became effective. Under this legislation the Air Board ceased to exist and its functions were assumed by the Minister of National Defence.

In the re-organization of the air services under the new Department, practically all civil positions were abolished. No recognition was given to the patent fact that a large part of the administration of aeronautics dealt with purely civil functions which had little relation to the Air Force.

The necessity for a change in this organization soon became apparent and in 1927 the administration of the aeronautical activities of the Department was divided into four directorates:—

(*a*) The Royal Canadian Air Force.
(*b*) Civil government air operations.
(*c*) The control of civil aviation.
(*d*) Aeronautical engineering.

The Royal Canadian Air Force was continued as part of the Branch of the Chief of the General Staff and the three others, which dealt with civil matters in large measure, were placed directly under the Deputy Minister, as civil head of the Department.

This new division of duties was satisfactory as far as the administration of the Royal Canadian Air Force and Civil Aviation was concerned but left a measure of divided responsibility in regard to the other two branches. A more satisfactory solution was found in 1930, when, with the transfer of the natural resources to the provinces, Civil Government Air Operations were greatly reduced and that Branch and the Aeronautical Engineering Service were again absorbed by the Air Force, Civil Aviation remaining as a separate civil branch under the Deputy Minister until its transfer to the Department of Transport on its formation in 1936.

*Royal Canadian Air Force*

Under the Department of National Defence the Air Force was re-organized as a permanent force. The highest


**Fig. 4—Expenditure on Air Services.**

educational and physical qualifications were set for entry of both officers and men. Wider experience was gained by the training of selected officers by special courses in Royal Air Force training establishments, the Air Force Staff College and later the Imperial Defence College, and by a system of exchange of officers with the Royal Air Force.

Space will not admit of following its history through the intervening years. It must suffice to say that today the Royal Canadian Air Force is coming to be recognized as perhaps the first line of Canada's defence. It is being strengthened materially by the provision of modern aircraft. New bases are rapidly being built for training its increased personnel. Non-permanent squadrons have been formed in the principal cities where young Canadians,

Courtesy of Royal Canadian Air Force.

**Fig. 5—R.C.A.F. Base on Hudson Bay Railway, Cormorant Lake, Man.**

normally employed in civil pursuits, can participate in the work of the Air Force as they have done for generations in the non-permanent Militia. The authorized strength is today 155 officers and 969 men.

*Civil Government Air Operations by the Royal Canadian Air Force*

The usefulness and practical nature of the civil government air operations developed by the Air Board and the support they had received from all quarters made their continuance necessary, and for some years a large part of the funds available for Air Force purposes was devoted to such operations. This tended to prevent the development of the Air Force on a scale commensurate with its position in a well balanced defence programme.

The work between 1923 and 1930 was based on the forest services in the prairie provinces, which were still under Dominion jurisdiction. The provinces of Ontario, Quebec and British Columbia had assumed responsibility for their own flying when the Air Board was abolished. With the development of new methods of aerial survey this interesting phase of the work increased rapidly and was extended to include surveys in all provinces and territories. In 1931, with the transfer of the natural resources from Dominion control to the provinces, the forest operations came to an end. Civil Government Air Operations are now confined almost wholly to photographic surveys and transportation for Dominion services in the remoter regions. (See Fig. 6).

Arrangements were made with the governments of Manitoba and Saskatchewan to help them establish provincial air services to carry on part of the work hitherto undertaken in their northern areas by the Royal Canadian Air Force. Certain bases and equipment were turned over to them for this purpose.

*Control of Civil Aviation*

The control of civil aviation under the Department of National Defence was, at first, a relatively small matter. The administration of the air regulations and licensing of civil aircraft and aviation personnel were provided for in the Branch of the Secretary of the Royal Canadian Air Force, and Air Force officers were lent for the performance of these duties. The re-establishment of the

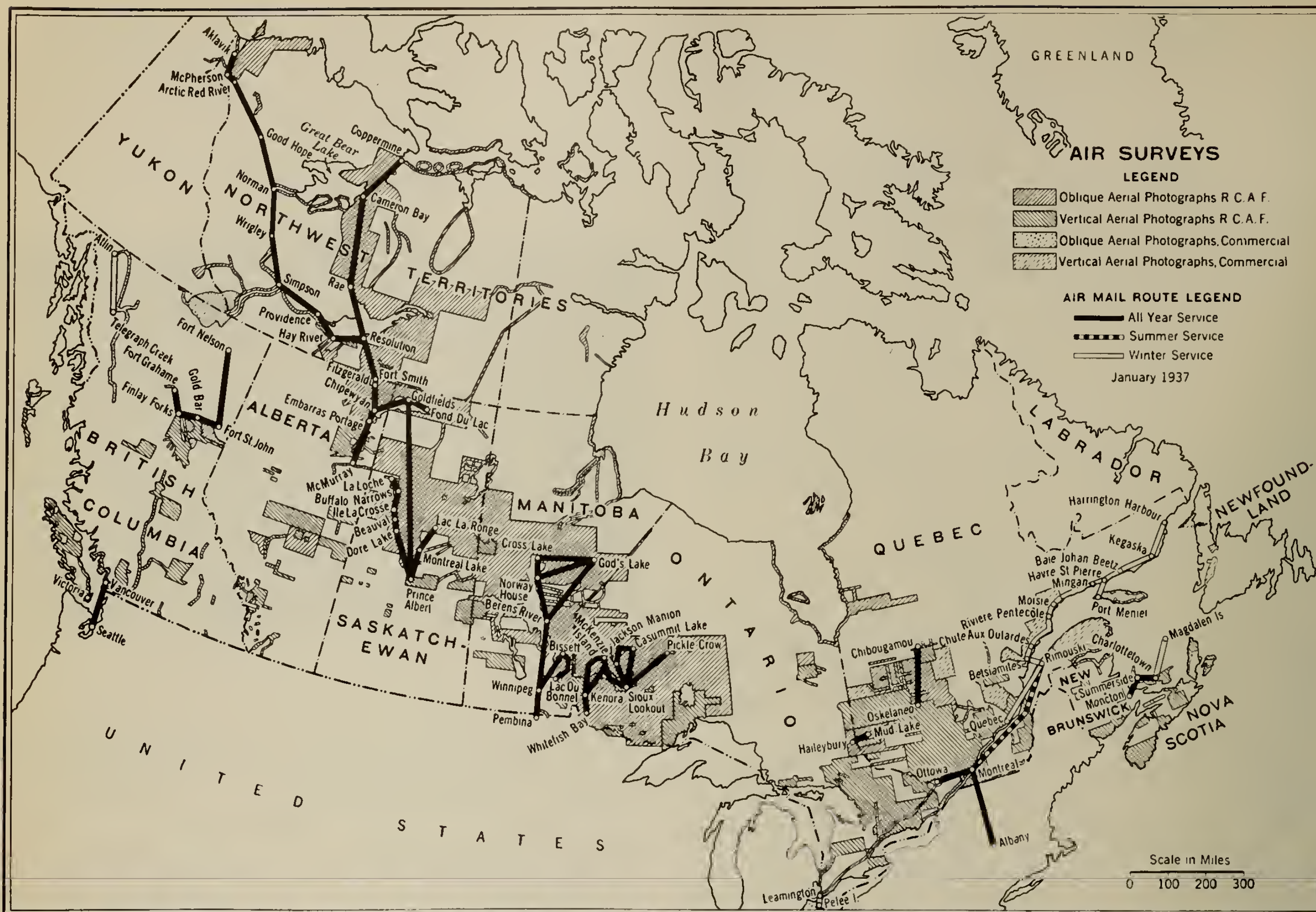



**Fig. 6—Air Surveys and Air Mail Routes in Canada.**

Civil Aviation Branch under the Deputy Minister was found necessary in 1927. The Secretary's Branch of the Royal Canadian Air Force became the Civil Aviation Branch and from that time all appointments were filled by Civil Servants.

In 1928, when construction of the trans-Canada airway was decided on, the division of the branch into separate Air Regulations and Airways Divisions became necessary. The former is charged with the inspection and licensing of aircraft, the examination of pilots and air engineers and the supervision of the Air Regulations generally, while the latter is charged with airway and airport surveys, the location and construction of aids to navigation on the airways, including intermediate aerodromes, lighting, the co-ordination of the radio and meteorological services and the licensing of airports and seaplane bases.

*Aeronautical Engineering Division*

The Aeronautical Engineering Division developed gradually from the appointment in 1920 of a civilian Director, Lieutenant Colonel E. W. Stedman, O.B.E., M.E.I.C., of the Technical Branch of the Air Board. The Air Board commenced to investigate the structural design of aircraft for airworthiness purposes, but progress was slow owing to the necessity for training a technical staff, for technical and supply duties.

From the earliest days the Branch has worked in the closest liaison with the Air Research Committee upon research problems connected with flying conditions which are peculiar to Canada, particularly those problems involved in winter flying.

In 1922 the Air Board was transferred to the Department of National Defence and the Technical and Equipment Branch was re-organized from a civil to an Air Force basis under an Assistant Director, C.A.F. During this year a supplementary estimate was obtained for the construction of a building at Toronto University to house the wind tunnel, thus allowing the only wind tunnel then available in Canada to continue in operation.

The next few years were mainly noteworthy for the training of personnel and the building up of a staff capable of undertaking any investigations that might be required. This staff was obtained by sending Air Force officers to England for training in aeronautics at the Imperial College of Science and Technology, and by the appointment of civilian engineers, or junior engineers for training in this highly specialized branch of engineering.

On July 1st, 1927, the Air Force was re-organized and the Technical and Supply Branch was renamed the Aeronautical Engineering Division "to act in a consulting capacity respecting all technical and engineering matters pertaining to the Air Services, and the carrying out of duties prescribed by the Air Board Act and Regulations thereunder."

With the re-organization the Aeronautical Engineering Division was formed into three main sub-divisions. (1) *The Research and Design Branch* to take charge of all engineering matters in connection with aircraft used by the Department of National Defence, modifications, design of camera mounts and skis, supervision of type trials, collection and distribution of technical information and co-operation with the Air Research Committee. (2) *The Airworthiness*

*Branch* to check the design of aircraft for which application for type certificates of airworthiness had been received by the Civil Aviation Branch, and the study of new methods of calculation to deal with progress in the art of aircraft construction. (3) *The Aircraft Inspection Branch*, divided into a number of detachments distributed throughout the country, to inspect aircraft under construction or during overhaul at manufacturers' works and to assist the Civil Aviation Inspectors.

An agreement in 1928 with the United States Government for the mutual recognition of certificates of airworthiness necessitated a study by the Airworthiness Branch of the methods of calculation used in the United States. Since that date both British and United States methods of calculation have been used in the Airworthiness Branch for domestic certificates, but for export purposes the British methods of calculation and International Convention for Air Navigation factors have always been employed.

The expansion of the National Research Council in 1929 to include a section devoted to Aeronautic Research provided much better equipment than had previously been available in Canada, and this has been of great assistance to the Aeronautical Engineering Division.

With the formation of the Department of Transport in 1936, the Division was divided to provide some of the personnel required for a separate aeronautical engineering staff for the new Department, which will in future handle all Civil Aviation questions.

### The Department of Transport

Stability in the organization of the air services of the Dominion was finally reached after the many changes, of which an outline has been given above, by the complete separation of its civil and military functions. The former was transferred to the new Ministry of Transport on its formation on November 1st, 1936, and the latter remained with the Army and Navy in the Department of National Defence. As long as both services were small, the advantages of combining their administration in one department were manifest. Civil aviation has now become so important a part of the transportation system of the Dominion that it can best be administered by the organization dealing with the railway, canal, marine and highway services, to which it is complementary.

No duplication of effort follows this change. The only new service required is the formation of an Aeronautical Engineering section in the Department of Transport, which will deal with civil aircraft, relieving the Royal Canadian Air Force engineering staff of much work which had no relation to its proper functions.

### Provincial Air Services

After the Air Board's operations were discontinued at the close of 1922, the Ontario government contracted with the Laurentide Air Service for their flying. In 1924 they established their own air service as part of the Provincial Forest Branch and have continued it on this basis until the present time. A central depot and base was established in 1924 at Sault Ste. Marie and ten sub-bases and many refuelling bases in the forest areas in the northern and western parts of the province have been provided, as required.

In 1931, when the control of the natural resources of the Prairie Provinces reverted to the provinces, the Royal Canadian Air Force withdrew their forces and these provinces accepted responsibility for their own forest fire protection.

The province of Manitoba during 1931 contracted with Canadian Airways for this work but in 1932 followed the example of Ontario and formed its own air service, with its principal base at Lac du Bonnet.

The province of Saskatchewan also operated its own flying service from 1933 to 1935. In both cases flying boats were given by the Department of National Defence to help start the new organization.

### Commercial Flying

After the armistice, aircraft were cheap, as governments were disposing of surplus war stocks. Pilots invested their war gratuities in the hope of establishing successful air transport companies. Their only outlet was exhibition flying, joy riding and flying instruction. Once the first curiosity of the public was satisfied the demand for such flying fell off and many of the smaller companies were forced out of business. Their sponsors forgot that time was required to build up the ground services, evolve new types of aircraft and convince the public that air transport could play a useful part in the normal life of the community. Those who were content to confine their activities to work for the forest services and transportation in the northern parts of the country reaped their reward and were able to operate on a self-sustaining basis.

As has been noted earlier in this review, the first tests of aircraft in civil work were made at Grand'Mère in the summer of 1919. The example of the Laurentide Company was followed by Price Brothers, who purchased aircraft for the use of their forestry service in Quebec. In 1922 these companies felt that their flying could be done to better advantage by separate organizations, which would be free to expand their field of operation and so reduce the cost to the parent company.

The Laurentide Air Services Limited was established in 1922 with six aircraft and during that year did over

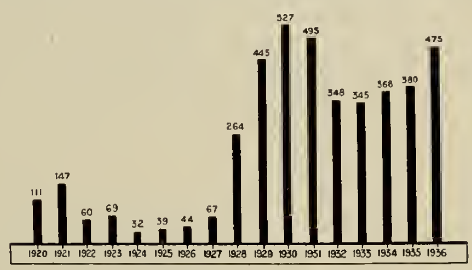



Fig. 7—Registered Aircraft.

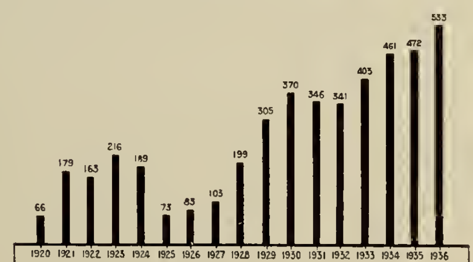



Fig. 8—Licensed Air Engineers.

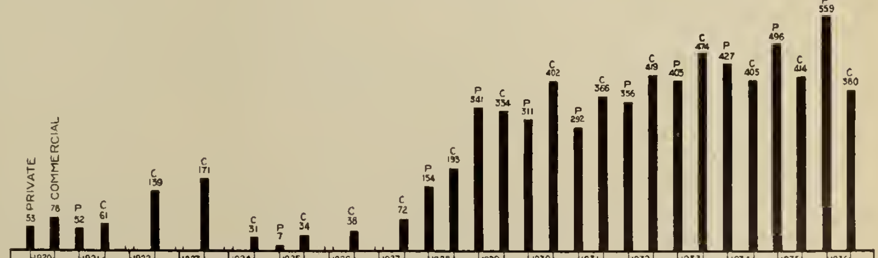



Fig. 9—Licensed Pilots.

seven hundred and eleven hours flying, including work for the Laurentide Company in Quebec and a large contract for the provincial government of Ontario for mapping the forest types in northern Ontario between the National Transcontinental Railway and James Bay.

In 1923 the company increased their fleet to twelve aircraft and obtained a contract from the Ontario government for fire patrols as well as for type sketching. Their flying time was approximately fifteen hundred hours for the year.

Fig. 10—Junkers 52, Payload on Floats 4,500 lb.

A new company, Dominion Aerial Explorations Limited, was formed in 1923 by the late Captain H. S. Quigley, A.M.E.I.C., who had been chief pilot for Price Brothers. In addition to contract work for Price Brothers, they took over, on a contract basis, the work hitherto done by the Air Board in the Roberval district for the Provincial Government of Quebec and extended their forest reconnaissance flights to the little known and remote areas on the north shore of the Gulf of St. Lawrence as far east as the Straits of Belle Isle.

The Fairchild Aerial Surveys Company was also formed in this year and, like the Laurentide Air Services, had its inception in the interest of Mr. Ellwood Wilson, Grand'Mère, in forest conservation work. The company was formed primarily to do photographic work and not flying, but it found that the ordinary aircraft available had not sufficient ceiling to undertake photography to good advantage. They, therefore, were forced to purchase their own aircraft and took over the original base at Grand'-Mère when the Laurentide Air Services moved its headquarters to Three Rivers.

From these modest beginnings commercial aviation has made rapid progress in all parts of the Dominion and by hard work, resourcefulness and concentration on immediately practical and economic operations, has maintained itself wholly without subsidy to the present day.

The first regular freight and passenger service was inaugurated in 1924 by the Laurentide Air Service, using H.S. 2L boats in summer and ski planes in winter. Over 1,000 passengers, 78,000 pounds of freight and 15,000 letters and telegrams were carried between Haileybury and Rouyn during the first six months of operation. Rouyn is still a centre of flying activity from which radiate regular services to the many new mining fields since discovered in northwestern Quebec.

In 1925 further pioneering was done by an expedition organized by Lieutenant-Colonel Scott Williams to prospect in northern British Columbia. Flying a Vickers Viking he penetrated from Wrangell, Alaska, into Dease Lake, and from a base there explored the upper waters of the Liard and Yukon Rivers, hitherto almost inaccessible.

Seaplanes were flown during the spring of 1924, 1925 and 1926 for the owners of the Newfoundland sealing fleet to spot the herds of seals on the ice floes and guide the sealers to them. This meant flying from continually shifting ice floes off the Labrador and Newfoundland coasts over vast stretches of water covered with ice floes in the early spring of the year.

Nineteen twenty six saw an all round increase of fifty per cent in the amount of flying done by commercial operators in Canada. Gold discoveries at Red Lake and elsewhere in northwestern Ontario made new outlets for commercial air services similar to the organization at Rouyn; Hudson and Sioux Lookout, Ontario, became centres of activity for these.

Mr. J. V. Elliott, of Hamilton, was a pioneer in this venture in which he was joined by a new Fairchild Company formed for the purpose. They took over the Rouyn service and also established another in the Red Lake district, carrying 576 passengers and 24,000 pounds of freight before the end of the season.

Aircraft re-entered the Mackenzie River basin in this year. The Vickers Viking used the year before in northern British Columbia was flown from Lac la Biche into the Great Slave Lake district by C. S. Caldwell and a base established at Fitzgerald, from which exploration flights were made into the country north and east of the Slave river, transporting prospecting parties in the area.

Commercial flying was also started by D. R. MacLaren on the Pacific coast and Captain H. A. Oaks, an ex-war pilot and a mining engineer formerly pilot with the Ontario Air Service, began a passenger, express and mail service from Sioux Lookout to Red and Woman lakes, with a Curtiss Lark seaplane. Later in the year he took over the management of Western Canada Airways Limited, which had been formed by Mr. James Richardson, of Winnipeg, to engage in air transport in western Canada.

Nineteen twenty seven saw the rapid expansion of work to meet the growing needs of the prospectors and mining companies. A study of the statistics on page 471 will show the continuous increase in the carriage of passengers, freight and mail, almost wholly due to such services. They show the early flow of the post-war tide, the ebb after the first enthusiasm was spent, then a lull, and from 1926 on a steady growth which still continues.

No factor has had a greater effect in the expansion of our mining industries than the adoption of air transport by the prospector and the mining companies. Aircraft now penetrate with ease and certainty to the remotest parts of the Dominion, and travel and transport by air all through the North has become commonplace.

The pioneer companies in eastern Canada were merged in 1928 into Interprovincial Airways by General MacBrien, including Dominion Aerial Exploration Limited, the Fairchild companies, the Laurentide Air Services and J. V. Elliott, while Western Canada Airways extended their operations from northwestern Ontario into Manitoba and the Mackenzie area and later absorbed Commercial Airways, of Edmonton, and Pacific Airways, of Vancouver. Two years later Canadian Airways Limited was formed by the union of Interprovincial Airways with Western Canada Airways and became a Dominion-wide organization.

Many companies have been organized since to participate in this work and have played an important part in its expansion. These include General Airways Limited, formed in June, 1928, by Captain A. Roy Brown, and Dominion Skyways Limited, formed in 1935 by H. de M. Molson and Air Vice-Marshal W. A. Bishop. Harvey St. Martin, a pioneer in the work in Quebec, has continued his independent operations from year to year with a high measure of success. In the west mention should be made of Mackenzie Air Services Limited, formed by W. Leigh

Brintnell in 1932; Starratt Airways and Transportation Limited, formed in 1932; Arrow Airways, by Harvey Webber and Jack Hone in The Pas in 1932; Wings Limited, Winnipeg; and United Air Transport Limited, formed in 1934 by G. M. G. McConachie, of Edmonton.

### Air Mails

The transport of mails by air in Canada has two phases:—

(1) Service to outlying communities not now served by roads or railways. In such cases there is no need to consider flying by night and favourable weather may be waited for. Such services are flown by seaplane in summer and skiplanes in winter. The surfaces of the many lakes and rivers in northern Canada provide admirable bases without expense, although flying is liable to interruption for a few weeks in the spring and fall during the break-up and freeze-up periods. Notwithstanding this drawback, remarkable efficiency is attained.

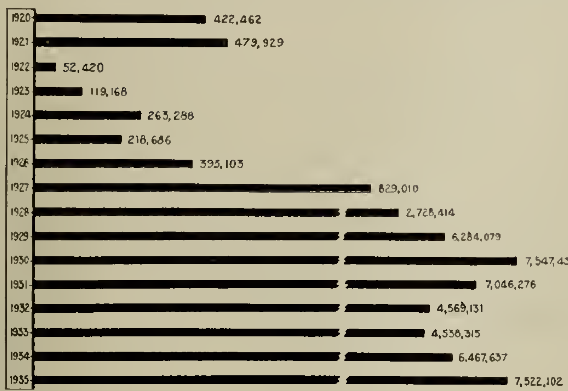



**Fig. 11—Aircraft Mileage.**

(2) Inter-city air mail services require a very different form of organization. They must show a material saving of time over the present railway or road services. To do this night flying is essential on many airways. The service must be maintained all the year round, in all weathers, and success depends on regularity and punctuality.

Regular scheduled services cannot be operated without adequate terminal airports and intermediate aerodromes, lighted for night flying; efficient communication and radio services and an extensive meteorological organization. They call for speedier aircraft of higher horse power and can only be operated successfully under mail contracts with the Post Office or other forms of government subsidy.

As has been previously noted, a study was made of the possibilities of inter-city air mail services in 1920 and it was decided that these were too costly for consideration at that time. The development of air mails to outlying districts had been growing up naturally with the inauguration of air transport services to the mining communities. The Post Office Department had, in 1924, given permission to northern operators to carry mails and had permitted them to issue twenty-five cent "stickers" to pay for the service. The regularly with which the mails had been carried under difficult conditions with no assistance or subsidy proved that the carriage of mail was not only feasible in northern Canada, but was much more efficient than the means hitherto used. Contracts were let in the autumn of 1927 for air mail services in outlying districts as follows:—

(*a*) *Murray Bay - Seven Islands and Anticosti (Winter Service)*

The scattered communities on the River and Gulf of St. Lawrence are accessible in summer by water but in the winter were dependent on mails drawn by sleigh as far as Bersimis and thence by dog team twice during the winter as far as the Straits of Belle Isle. The time taken for the conveyance of mail was six weeks and the cost high. The whole area is now served regularly by air, receiving mails twice a week. Travellers can come and go along the coast; facilities for medical aid and the hospitalization of serious cases have proved of great value.

(*b*) *Moncton - Magdalen Islands*

The Magdalen Islands were isolated for several months in the year and were wholly dependent on radio for communication with the outside world. Winter mails were occasionally floated ashore in barrels and picked up on the north coast of Prince Edward Island. Mails, passengers and express now pass regularly by the winter air service.

(*c*) *Rolling Portage - Red Lake*

This was the first of the regular air mail services to the mining areas and is typical of that class of work. The convenience to the inhabitants of these mining districts is very great.

(*d*) *Leamington - Pelee Island*

Each winter communication between Pelee Island with the mainland in Ontario is interrupted by ice floes on Lake Erie. The mails used to be carried by row boats, which could be hauled over the ice and launched again in the open water. This cumbersome method has been completely superseded by the carriage of mail by air. The distance is short and the cost is small.

The advantages of such air mails are obvious. The Post Office has extended these services year by year until


**Fig. 12—Pounds of Freight Carried.**


**Fig. 13—Pounds of Mail Carried.**

Fig. 14—Trans-Canada Airway Intermediate Aerodrome, Caddy Lake, Man.

they now serve all outlying parts of the Dominion. The Postmaster General stated recently in the House of Commons that the air mail business for the fiscal year 1936-37 had been profitable, the cost being $284,000 and the revenue $605,000. (See Figs. 6 and 13.)

The Post Office Department have an agreement for the interchange of air mail traffic with the Postal authorities of the United States. This gives Canada the full advantage of the air mail system in the United States and its extensions abroad in Central and South America and later on the trans-Pacific service. International services giving air mail connections in western, central and eastern Canada have been made from Vancouver to Seattle, Winnipeg to Chicago and Montreal to New York.

In regard to trans-Atlantic mail service it was found that incoming and outgoing trans-Atlantic mails could be materially hastened by flying the urgent matter from Rimouski to Montreal. Arrangements were made with the British Post Office to pouch special mails separately. These are transferred to the aircraft waiting at Rimouski and flown to Montreal. In the same way, mails received in Montreal after the steamer had sailed can be placed on board at Rimouski. Experimental flights were made in the fall of 1927 by seaplane but it was found that the absence of a sheltered base near Father Point prevented the maintenance of a regular schedule. A suitable aerodrome was located near Rimouski Wharf and since 1928 this service has been continued each year during the summer season of navigation.

Experiments were made in September, 1931, and again during the Imperial Conference in 1932 to make a further saving of time by the extension of the mail service to the Straits of Belle Isle, where contact was made with the incoming and outgoing steamers. Thus one-third of the trans-Atlantic journey was made by air. During the past two years an all-air trans-Atlantic mail service has been under consideration and plans for the extension of the ship to shore service have been abandoned in favour of the all-air route.

A preliminary conference was called in St. John's, Newfoundland, in 1933, to consider the trans-Atlantic air service, and at a conference of representatives of the Canadian, United Kingdom, Irish Free State and Newfoundland Governments in Ottawa in November, 1935, an agreement for co-operation was reached. The Canadian Government has accepted responsibility for the radio and meteorological services in Newfoundland and eastern Canada necessary for its efficient operation and preparations on the ground are well advanced. It is expected that trial flights will commence in June, 1937. Trans-Atlantic air services are the subject of a special paper in this series and therefore will not be considered at greater length.

### The Trans-Canada Airway

The success of the inter-city air services in Europe and the steady growth of the United States airway system led in 1927 to a reconsideration of Canada's position

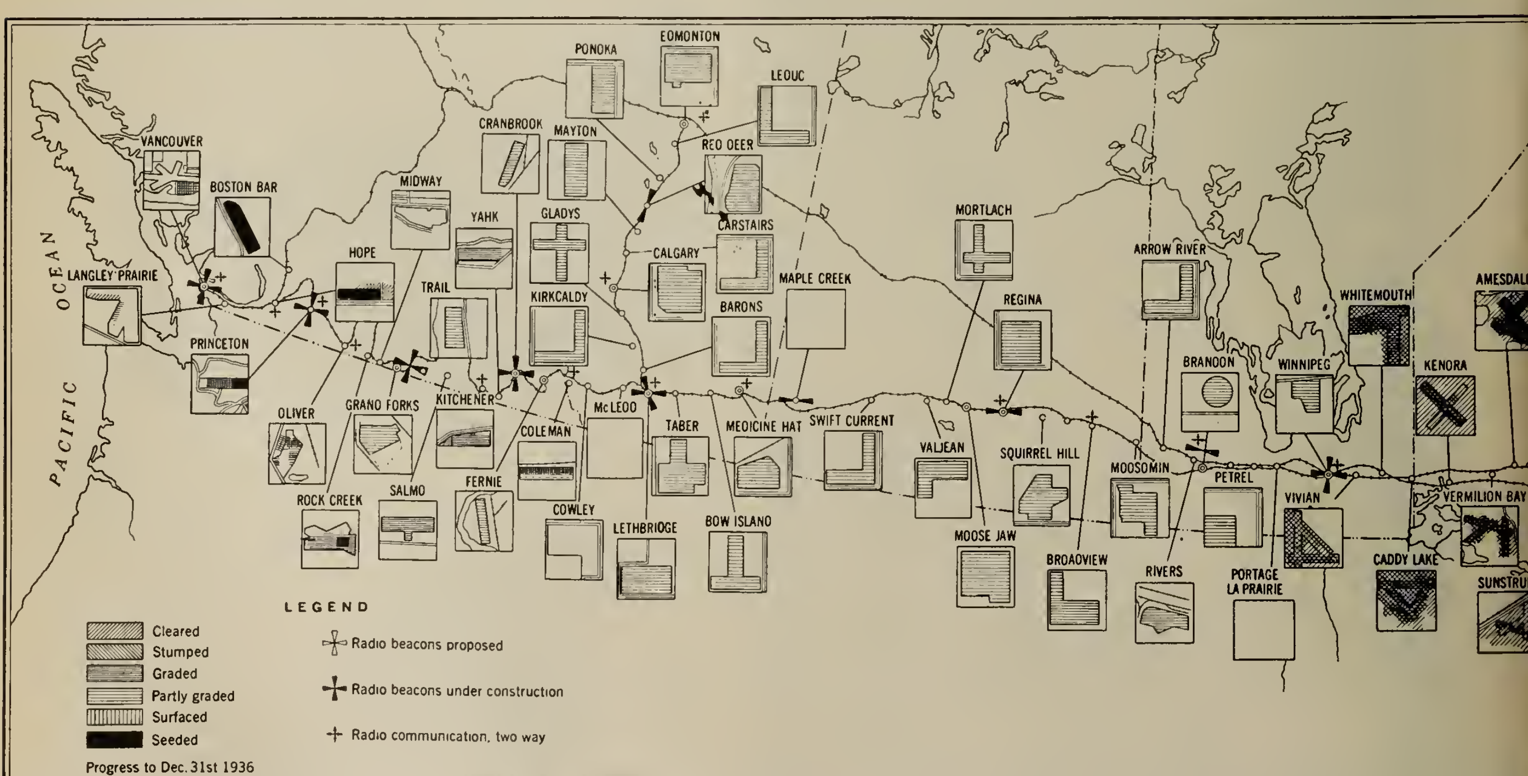



Fig. 15—Map showing

in regard to inter-city air mails. The cost of building the trans-Canada airway was estimated at from $5,000,000 to $6,000,000 but revenues were buoyant and it was felt that it would become an essential part of our transportation system before many years had passed. Canada, as one of the great trading nations of the world, must move with the times. Signs were evident of the desire of the United States air transport companies to tap traffic in the main centres of population and industry in Canada, which are not far from the international boundary, and to feed it into the United States airway system. In 1928 permission was given to commence the survey for a Canadian transcontinental airway.

Due to the activities of the flying clubs and the support they were receiving from their communities, a chain of airports was coming into being from coast to coast. In the Maritime provinces, Sydney, Halifax, Saint John and Moncton all secured sites and were busy constructing airports. In Ontario, Kingston, Hamilton, St. Catharines, Brantford, London and Windsor were all moving, while in Toronto the club had secured premises which, with improvement, would serve the purpose, and at Montreal the airship base at St. Hubert made an admirable site for an aerodrome. In western Canada all the principal cities were active, so that the foundation for the trans-Canada airway was provided by the municipalities it would serve when completed.

Intermediate aerodromes to fill the gaps between these major airports, the lighting required for night flying, and the radio and weather services would be the contribution of the Dominion Government, who also pay for the carriage of the mails by contract with the Post Office Department, which stoutly backed the project.

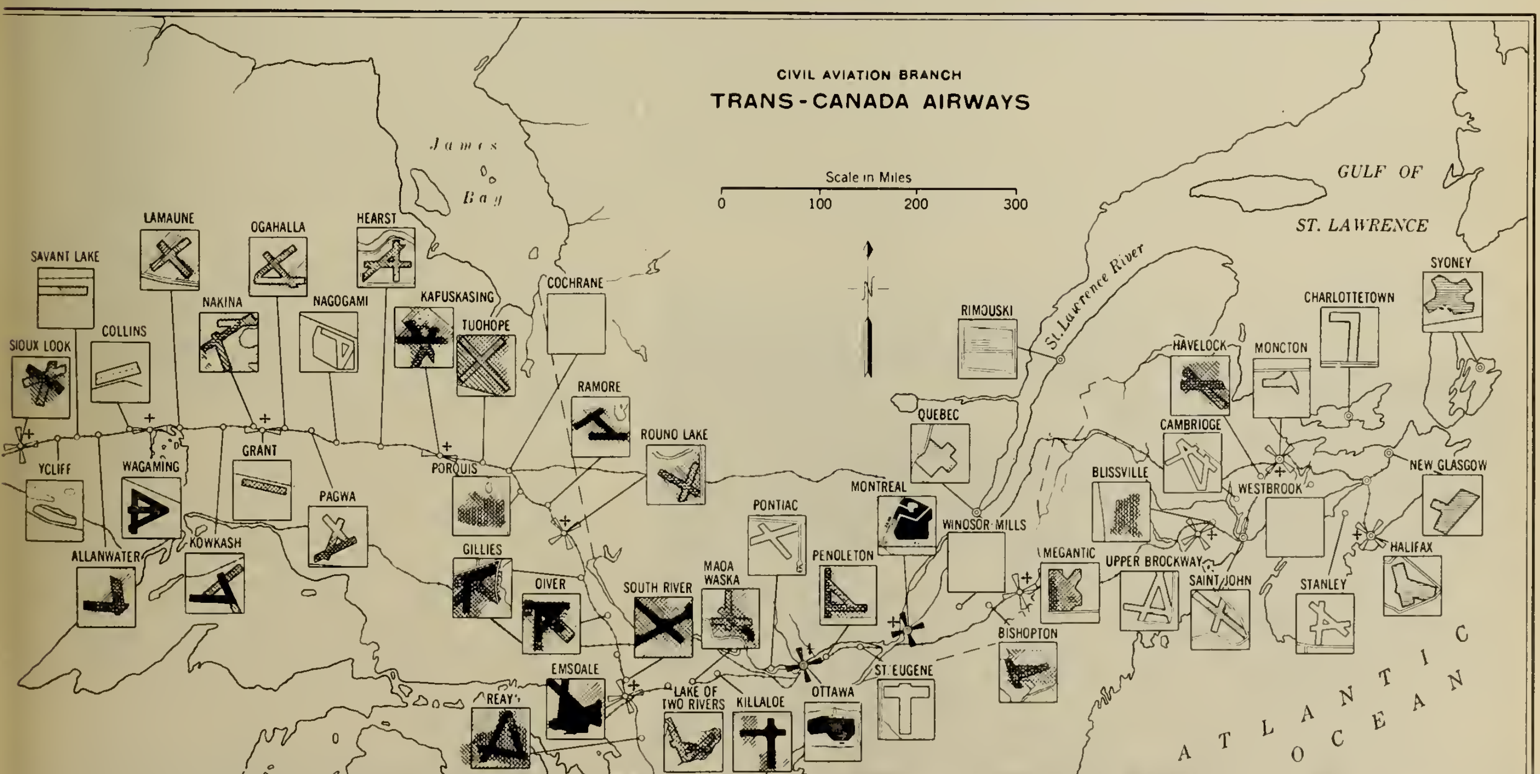
That section of the airway lying in the prairie provinces presented the simplest problem and was tackled first. By flying the mails over night between Winnipeg and Calgary a twenty-four hour saving in the transcontinental journey could be made without waiting for the completion of the more difficult sections through the mountains and the rugged section in northern Ontario. The location of the intermediate aerodromes in the prairie section, the leasing and improvement of the necessary properties, and the installation of the lighting, radio and meteorological services were completed in March, 1930, and a nightly service was inaugurated under contract with the Post Office between Winnipeg and Edmonton, via Calgary, in the first place, and later via Lethbridge and Calgary.

A contract for a daily air mail service from Moncton to Montreal, Kingston, Toronto, Hamilton, Brantford, London, Windsor and Detroit was let by the Post Office at the same time and arrangements were made with the United States air mail service for the conveyance of mail between Detroit and Pembina, south of Winnipeg, over the United States airway, so that there was a through connection by air between Moncton and Edmonton by the spring of 1930.

Surveys were continued through the Rocky Mountains to determine the best route from the prairies to Vancouver and also east of Winnipeg. These showed that the Crow's Nest route through southern British Columbia was shorter, the climate was better, it passed through a more settled area and the difficulties of constructing aerodromes were less there than on the alternative routes via the Yellowhead and Kicking Horse Passes. Aerodromes were already in existence on the route at Fernie, Cranbrook, Trail, Grand Forks and Chilliwack.

On March 31st, 1932, the necessity for economies in all public services forced the Government to discontinue the inter-city air mail services. Permission was given to maintain intact those sections of the airway which had been constructed and to continue surveys for its completion.

A year later, the need for finding suitable employment for the many thousands of single, homeless men in different parts of the country led to the establishment of construction camps on various projects. Airway construction work was specially suitable for this purpose and authority was given to commence construction of the intermediate




the Trans-Canada Airway.

aerodromes in British Columbia and in Ontario, Quebec and the Maritime provinces. The locations for all intermediate aerodromes in British Columbia had by that time been fixed, so that clearing and grading could be proceeded with at once.

In northern Ontario the task of finding the best route through the thousand miles of forest, lake and rock of the Precambrian Shield was a difficult one. It was advisable that the airway should keep in close touch with existing railway lines there. The airway surveys had showed that the route along the line of the National Transcontinental Railway from Winnipeg east to Cochrane was preferable to that followed by the C.N.R. line or the C.P.R. line. It passed through easier country; the climate, though colder, was more even than on the route by the shores of the Great Lakes, and it would serve the growing mining districts in northern Ontario and Quebec. Sites on which aerodromes could be constructed at a reasonable cost in the Laurentian country at approximately thirty-five mile intervals were hard to find. The clearing, stumping and grading of the sites provided a suitable task for the re-employment of single, homeless men and camps were established at all sites during 1934 and 1935 and much valuable work was done through this scheme. Construction was extended also through the eastern townships of Quebec and the Maritime provinces. On July 1st, 1936, the Government decided that the camps should be closed. The Civil Aviation Branch has continued construction by day labour or contract since then.

By July 1st, 1937, the western section should be ready for operation, complete with lighting, radio and meteorological services, and one year later the remainder of the airway from coast to coast should be sufficiently far advanced to enable safe operation to be conducted by night or day.

Legislation is now before Parliament creating a trans-Canada operating company, which will be entrusted by the Government with the operation of the airway. Tentative schedules arranged with the Post Office Department call for mail posted at the close of the business day in Montreal, Ottawa, Toronto and other eastern cities to be delivered by first mail the next morning on the prairie and first afternoon post in Vancouver.

### Airship Services

At the Imperial Conference in 1926 the support of Canada was promised by the Prime Minister in the development of a system of Empire air communications by airship. Under this agreement Canada constructed an airship base at St. Hubert, seven miles east of Montreal. The site was chosen by Major Scott, Director of Airship Development in the Air Ministry, after a survey of all likely sites in eastern Canada.

The construction of the base was undertaken in conjunction with the Public Works Department, who became responsible for the engineering work involved, the design and construction of the mooring tower and other facilities, including a hydrogen plant and mooring winches. The construction work was completed early in 1930.

The crew for the mooring tower was lent by the Royal Canadian Navy. Lieutenant-Commander A. B. Pressy, R.C.N., and four experienced naval ratings had been sent to the Royal Airship Works at Cardington to gain experience in airship operation during the trial flights of H.M. Airships R.100 and R.101.

The wireless system was organized by the Royal Canadian Corps of Signals and the Meteorological Branch of the Department of Marine arranged for a special study of trans-Atlantic weather in co-operation with the Meteorological Service in the United Kingdom.

On the evening of July 28th, 1930, notification was received that H.M. Airship R.100 would leave Cardington for St. Hubert early on the morning of the 29th. The airship arrived over Montreal on the evening of the 1st of August and was successfully moored at dawn the next day. During her stay at St. Hubert, a successful flight over Ottawa, Toronto and Niagara was made and the airship was then refuelled, regassed and reballasted and was ready for departure on August 13th. She slipped her mooring cable at 9.30 p.m. Quebec was passed before midnight, Father Point at 2.00 a.m. and Belle Isle on the 14th. On the morning of August 16th she was reported over Lundy Isle in the Bristol Channel and before noon was safely moored again at Cardington.

Many valuable lessons were learned during the flight. So far as the Canadian part in the experiment was concerned, the handling of the airship, her servicing and repair at the mast and the ease with which she was moored and unmoored proved conclusively that the design and construction of the Canadian base was sound. A crew of fourteen men, of whom only five had ever seen an airship before, handled this airship with ease and certainty.

The destruction of the sister airship R.101 in France in the fall of 1930 while en route to India led the Air Ministry to reconsider their plans and no further use has since been made of the airship equipment at St. Hubert; it has been maintained in working order pending a final decision on airship services.

Courtesy of Royal Canadian Air Force.

Fig. 16—H.M. Airship R.100. St. Hubert, 1930.

In justice to the staff of the Air Services in Canada, civil, military and technical, it should be stated that their unanimous opinion was that while airships might prove efficient under certain conditions, the North Atlantic ocean was not a suitable proving ground for their development.

### Flying Club Movement

In the fall of 1927, two urgent problems faced the Civil Aviation Branch. The first was the provision of municipal aerodromes in all parts of the Dominion. Flying had been confined to seaplane and ski operations and there were no improved aerodromes in the country, though a few fields had been licensed for use. Before any Dominion-wide inter-city services could be inaugurated, proper airports were essential. The Dominion Government could not build airports in every municipality and the responsibility must be shouldered by the municipalities as their contribution to the airway system.

The other problem was the acute shortage of Canadian pilots. Even the Dominion and provincial government services had had to send to Great Britain to recruit the pilots they required for their work. There were practically no flying instruction facilities in the country and experience had shown that flying instruction was not a profitable venture. The flying club movement in Great Britain had been successful and it was considered that if a flying club could be organized in every important Canadian centre, both needs would be met.

The standard conditions, as approved by Order-in-Council, provide that any community pledging itself to provide the services of an instructor and an air engineer, a licensed aerodrome and adequate accommodation for the housing and maintenance of the machines, would be issued with two light aircraft by the Department in the first year, and in each subsequent year, if they supplied from their own resources a machine of an approved type, the Department would issue one further light aircraft. Further, the Department would pay to the club a grant of $100 for each *ab initio* pupil obtaining a private pilot's certificate.

Sixteen clubs were started during 1928 and in 1929 seven additional clubs. Their success has fully met the expectations of the Department. The following Table I shows the progress of the club movement:—

Table I

Summary of Flying Club Activities 1928-1936

| Year | Members | Aircraft in use | Members under instruction | Hours flown | Licences obtained | |
|---|---|---|---|---|---|---|
| | | | | | Private | Commercial |
| 1928 | 2,403 | 34 | 598 | 8,124.30 | 111 | 28 |
| 1929 | 5,233 | 65 | 904 | 16,612.50 | 175 | 58 |
| 1930 | 3,643 | 70 | 703 | 14,686.44 | 178 | 59 |
| 1931 | 2,915 | 72 | 673 | 11,507.32 | 111 | 48 |
| 1932 | 2,703 | 68 | 872 | 10,450.55 | 129 | 27 |
| 1933 | 2,075 | 68 | 499 | 9,971.59 | 120 | 26 |
| 1934 | 2,200 | 82 | 535 | 10,581.33 | 133 | 21 |
| 1935 | 2,400 | 81 | 536 | 13,819.31 | 165 | 33 |
| 1936 | 2,492 | 66 | 645 | 17,324.01 | 210 | 34 |

It may be noted that during the years of the depression the average cost to the Government of maintaining the flying clubs was little more than a thousand dollars per club per annum.

### Aircraft Industry

An aircraft industry to construct in Canada the aircraft required for military and civil flying was essential for the sound development of flying.

After the armistice, surplus war types of aircraft were thrown on the market at sacrifice prices and there was little or no demand for new aircraft. The industry ceased for the time being, but by 1923 the demand for civil aircraft built in Canada to meet Canadian conditions was such that the manufacture of aircraft began again.

Canadian Vickers were the pioneers. Their first contract was for eight "Viking" amphibians, a type which had been produced by the parent company in England. In 1924 they added a design staff to their organization and undertook the development of special types to suit Canadian conditions. Their first production was the "Vedette," a three-seater flying boat specially built for forest sketching, light transportation and aerial photography. This type has been most successful and is still in use for seaplane flying, instruction, forest patrols and forest type sketching. In 1925, the "Varuna," a twin engined flying boat, specially built for forest fire suppression in the prairies, and other types, were designed and built. Later the company built "Fokker" types and during 1936 the Northrop "Delta" under licence. They are now engaged on a contract for five "Stranraer" twin engined flying boats for the Royal Canadian Air Force in addition to other work.

Fig. 17—De Havilland Dragon "Rapide" Twin Engined Aircraft.

In 1927, with marked activity in flying and promise of further extensions, other companies entered the field, including the de Havilland Aircraft of Canada Limited, a branch of the parent company in Great Britain, and makers of the popular "Moth" aircraft. They built a plant for the service and assembly of aircraft in Toronto and during 1928 delivered sixty-two aircraft to users in Canada, including "Moths," the D.H. 61, a larger, general purpose biplane suitable for northern transportation and forest fire suppression work, and have since then continued to play an important part in the supply of aircraft in Canada, including the "Tiger," "Puss," "Hornet" and "Hawk" Moths; the "Dragon," "Dragonfly" and "Rapide" twin-engined types.

The Reid Aircraft Company established a plant at Cartierville aerodrome, Montreal, in February, 1928, and commenced the manufacture of aircraft to their own designs. In January, 1929, the Curtiss Aeroplane and Motor Company entered into an agreement with the Reid Aircraft Company and this firm was afterwards known as the Curtiss-Reid Aircraft Company, and later as Montreal Air Industries Limited. Finally, in 1935, the plant was taken over by the Noorduyn Aircraft Company Limited to manufacture the Noorduyn "Norseman" general purpose transport, designed specially to meet Canadian conditions. (See Fig. 18.)

In 1928 Armstrong-Siddeley Motors established a branch in Ottawa for the service, assembly and repair of their aero engines in Canada, including the well known 750 hp. "Leopard"; 455 hp. "Jaguar"; 225 hp. "Lynx"; 140 hp. "Mongoose"; and 85 hp. "Genet," while the allied interests of the Ottawa Car Company arranged with the A. V. Roe Company to establish a plant for the manufacture of the "Avro" types.

The two leading engine manufacturers in the United States also established assembly and service plants for their engines at Montreal—the Canadian Wright Company, the makers of the famous "Whirlwind" cyclone series of engines, and the Canadian Pratt & Whitney Company, the "Wasp" and "Hornet" engines.

The Fleet Company of Buffalo established a Canadian branch at Fort Erie in 1930. It was re-organized in 1936,


**Fig. 18—Noorduyn "Norseman" General Purpose Single-Engine Aircraft.**

is now wholly controlled in Canada and builds the well known "Fleet" trainer and is agent for "Waco" types.

The Boeing Company of Seattle established a branch plant in Vancouver in 1929 for the manufacture and service of their aircraft in Canada in co-operation with the Hoffar-Beeching Shipyards of Vancouver, who had previously acted as their agents to build flying boats and mail planes.

In co-operation with the Fairchild Aviation Corporation of New York, a group of Canadian business men organized the Fairchild Aircraft of Canada Limited early in 1929. A modern aircraft factory was constructed and production commenced in April, 1930. The Fairchild Company had, since the earliest days, been interested in Canadian aviation through the Fairchild camera. They became closely identified with the early experimental work, and later, in practical operations in transport and air services, they obtained a wide experience of Canadian operating conditions and have built their aircraft to suit them. Fairchild types—F.C.2 or "Razor Back," the "51," "71" and "82"—are known in every operating field. The design and production of a twin engined plane suitable for northern operations and a large, single engine freight carrier are now in hand.

Table II

Aircraft Industry—Statistics of Production
1923-1936

| | Number of aircraft built or assembled in Canadian factories | Number of aero engines built or assembled in Canadian factories |
|---|---|---|
| 1923 | 10 | |
| 1924 | 13 | |
| 1925 | 11 | |
| 1926 | 5 | |
| 1927 | 17 | |
| 1928 | 83 | |
| 1929 | 175 | 70 |
| 1930 | 116 | 32 |
| 1931 | 64 | 55 |
| 1932 | 12 | 3 |
| 1933 | 15 | 3 |
| 1934 | 21 | 10 |
| 1935 | 62 | 33 |
| 1936 | 86 | 53 |
| Total | 677 | 259 |

Table II gives some statistics of Canadian Aircraft production.

In addition to these aircraft manufacturing companies, other firms have specialized in the manufacture of floats and skis, including MacDonald Brothers in Winnipeg, who commenced with the manufacture of Edo floats and now do a general aircraft servicing business in addition to their float work. Elliott Brothers of Sioux Lookout were originally boat and toboggan builders. With the development of the mining industry in northern Ontario they had ample opportunity of studying the practical requirements for winter landing gears and have specialized in this work with notable success.

**Fig. 19—Fairchild Super "71" on Floats.**

Aeronautical Research

In 1919 the Air Board requested the Honorary Advisory Council for Scientific and Industrial Research (now the National Research Council) to organize an Associate Air Research Committee whose function would be the fostering of aeronautical research in Canada and the supplying of technical assistance to the Air Board in solving its problems.

The Committee was similar to the other associate committees of the Advisory Council which had been formed to deal with chemistry, mining and metallurgy, etc., and reported directly to the Advisory Council; copies of all its proceedings were sent both to the Advisory Council and to the Air Board. The members of the Committee were qualified by familiarity with scientific or aeronautical work.

The first meeting of the Committee was held on February 7th, 1920. The problems awaiting solution and those likely to arise in the near future were reviewed. Steps were taken to obtain information as to experimental work accomplished and in progress in England, France and the United States in order to avoid duplication. The aircraft industry was notified of the formation and objects of the Committee and suggestions were invited as to the lines of work which would be of assistance to the industry.

The next step was to discover what research facilities existed in the Dominion and what men were available to work in the field of Aeronautical Research. Enquiries were sent out to all the Canadian universities asking what their facilities were, what aeronautical research work had been done, what work was in progress or what work, if any, was contemplated in aeronautics.

In the years that followed the Committee were able to make financial grants to assist aeronautical researches carried out in various parts of the Dominion. The facilities of the University of Toronto wind tunnel were valuable both to the Committee and the industry, as likewise were those for engine research at McGill University and the University of Alberta, and the co-operation given by other universities and scientific men throughout Canada.

Some of the more important problems dealt with by the Committee are as follow:—

1. The winter operation of aero engines with special reference to starting conditions. This work covered an investigation of the running conditions, lubrication, cooling, etc., of aero engines at low temperatures. The starting and early running technique developed from this work was made a routine in the flying service for a number of years.
2. Effect of low temperature on lubricating oils and on the strength of materials such as spruce, ply wood, streamline wire and rubber shock cord.
3. Development of a controllable pitch propeller. Funds were provided for the construction of the experimental propeller and arrangements were made for it to be tested. The propeller was successful and has now been commercially developed.
4. The elimination of magneto noises in the radio-telegraphic receiving equipment for aircraft.
5. The development of a piezo-electric engine indicator.
6. The development of the most efficient type of windmill, a research that has a direct commercial and utilitarian value.
7. Aerodynamic investigations on tapered wings, wind-tunnel wall interference and the stability of flying boats.

The Committee now functions as a liaison between the aircraft manufacturers and operators on the one hand and the aeronautical laboratories of the National Research Council on the other, thus bringing together representatives of all organizations interested in Canadian aviation problems.

### The Engineering Institute of Canada and Aviation

This review of aeronautical activity in Canada would not be complete without a reference to the relations between the older, well established branches of engineering and The Institute itself to the new science. All aviation services, civil, military and technical, owe much to the interest, helpful support and ready co-operation received from engineers in all parts of the country and from them, in a corporate capacity, through The Institute. From the earliest days Institute meetings in all parts of the country have welcomed speakers on aviation and have provided a platform from which our work and aims might be made known.

Aeronautics is not a self-contained science, and calls for contributions from all branches of engineering: mechanical in its engine development, structural in aircraft design, electrical in lighting and radio, civil in aerodrome and building construction. Forest engineers and surveyors gave the air service its first opportunity to prove its value in Canada. In the development of aviation in Canada, engineers of all branches have played a notable part.

The Institute has been generous in welcoming as members many engaged in aviation. Co-operation between the Royal Aeronautical Society of Great Britain and The Engineering Institute of Canada has been close. It was decided some years ago that where a branch of The Institute desired to form an aeronautic section, this section would become automatically a branch of the Royal Aeronautical Society. The Montreal and Ottawa Branches immediately formed such sections, which hold meetings regularly for consideration of this particular phase of engineering work. The papers presented are printed in special supplements to the Engineering Journal.

Any member of The Institute can become a member of the aeronautic section, and by an exchange arrangement copies of the aeronautic section reprint of the Journal are sent to the Royal Aeronautical Society in return for copies of the Journal of the Royal Aeronautical Society, which are issued to members of The Institute belonging to the aeronautic sections. This arrangement also provides a much larger circulation for papers presented in Canada before the comparatively small audience of a local aeronautic section.

The election to the Presidency of The Institute in this, the Jubilee year, of G. J. Desbarats, C.M.G., Hon.M.E.I.C., is particularly gratifying to everyone connected with flying. As Deputy Minister of the Naval Service during the war, he administered the first Canadian air service. In the drafting of the Air Board Act in 1919 he lent advice and guidance. In the same year he encouraged the first trials of aircraft in forestry by authorizing the loan of two flying boats for this purpose. From 1923, when he became Deputy Minister of National Defence, till his retirement from the public service in 1933, he was responsible for the administration of aeronautics in Canada. His patience and imperturbability in the face of difficulty and discouragement, his balanced judgment and wise counsel in times of prosperity, and his ready sympathy at all times have gained for him the respect and affection of everyone in aviation. His great gifts as an administrator and his high conception of duty as a servant of the State have been a constant inspiration to those who had the good fortune to serve under him.

# Bridge Building

*C. R. Young, M.E.I.C.,*
*Professor of Civil Engineering, University of Toronto*

During the fifty years that have elapsed since the predecessor of The Engineering Institute was founded, the science of bridge building, along with whatever of art there is in it, has moved forward with amazing strides. Records of boldness, ingenuity and originality unsurpassed in any other country have been established in the bridge work done within our own borders.

### Fifty Years Ago

The late eighties found many new developments of importance under way. More permanent forms of construction had been forecasted in the construction of many iron bridges for the Grand Trunk Railway in the early fifties and, thanks to the pertinacity of Sandford Fleming, in the construction of many more for the Intercolonial Railway in the early seventies. Nevertheless, by far the greater number of bridge structures in Canada had been built of timber—the material that was closest at hand and easiest to work. Stone masonry had been used for piers and abutments, but, in strong contrast with the practice in Europe, very little use had, or has subsequently, been made of the masonry arch type of superstructure. Concrete was still a material to be used with great caution and seldom permitted to show itself above water level. As late as 1898, concrete closer to the surface than 20 ft. was not allowed in the substructure of the Alexandra cantilever bridge over the Ottawa river, at Ottawa.

**Fig. 1—Three Bridge Types at Windsor, N.S.**
**Half-deck plate girder spans, English riveted lattice truss spans of 1880, and pin-connected Pratt truss spans.**

As the nineties approached, fire hazards and short structural life were forcing the Canadian Pacific Railway to consider the replacement of many of its timber bridges. In order to speed up construction, and incidentally to lessen interest charges, much temporary work had been done on the transcontinental line, involving long, high timber trestles, timber truss spans up to 180 ft. in length and many timber pile or crib substructures. It was not long before these were forced to give way to steel.

Things were stirring, too, in the field of highway bridge construction. In Nova Scotia steel highway bridges had been built as early as 1883 and thereafter the use of wood for such structures rapidly decreased. In Ontario, the progressively poorer quality of local timber had reduced the life of wooden bridges to from eight to twelve years and the activities of the amateur bridge-builder, accepted for this type of construction, had greatly shortened the expectancy. Faulty joints, lack of counterbracing and excessive deflections soon racked many structures to pieces, if they by chance survived the passage of the neighbourhood traction engine.

A strong incentive towards the application of metal to bridge construction in bolder and more massive forms had been given in the successful completion of the famous Kentucky river cantilever in 1876, and the St. Lawrence river continuous bridge at Lachine, in 1886, according to the designs of C. Shaler Smith, as well as in the signal achievement of Sir John Fowler and Sir Benjamin Baker at the Firth of Forth. Steel was beginning to come to the fore with all of its fascinating possibilities, and, as the decade drew to a close, the first reinforced concrete bridge built in America was completed in Golden Gate Park, San Francisco.

With such a background the drama of Canadian bridge building rapidly unfolded. New materials, new forms, and new methods were devised and applied, with an outcome that we continue to contemplate with professional pride. In the pages that follow the progress during the half century now completed will be examined primarily in relation to the material of the superstructure and, within this classification, in accordance with the structural type. Substructures will be mentioned in a separate classification.

## STEEL SUPERSTRUCTURES

### Simple Plate Girder Spans

As a derivative of Robert Stephenson's tubular bridges, simple plate girder spans of considerable length had been built some time before the organization of the Canadian Society of Civil Engineers and many followed soon thereafter. C. Shaler Smith employed 80-ft. spans with rocker supports in the St. Lawrence bridge at Lachine, in 1886. The long span Howe truss wooden bridge of the Canadian Pacific Railway over the Jacques Cartier river, P.Q., was replaced in 1887 by 85-ft. deck plate girder spans on stone

**Fig. 2—Champlain Bridge, Ottawa River, Ottawa.**
**A highway deck plate girder structure, including four 125-ft. spans. 1929.**

**Fig. 3—C.N.R. Subway at Breslau, Ont.**
**Steel girders and floorbeams with reinforced concrete stringers and deck. 1931.**

masonry piers, giving an appearance in elevation strikingly like modern plate girder bridges. In the ensuing years, an increasing number of railway plate girder spans were

**Fig. 4—C.P.R. Half-Mile Bridge, Don Valley, Toronto.**
**Girder spans weighing 105 tons handled by single derrick. 1928.**

erected, both as replacements and as original structures.

Such novelty as has been associated with plate girder bridge construction in recent years has generally gathered about the method of erection. An unusual plan was followed in 1912 by the Dominion Bridge Company, Ltd., in the case of the C.P.R. bridge at Ste. Rose, P.Q., when 78-ft. deck plate girder spans replacing old 157-ft. through truss spans were moved along the old structure on flat cars, slung up to the trusses and lowered in place on their piers after the floor and lateral system had been taken out of the span to be removed. About the same time, the half-deck plate girder spans of the Dominion Atlantic Railway bridge at Windsor, N.S., shown in the foreground of Fig. 1, were erected by the same company, utilizing a light erection truss span which was dropped in place by a derrick and upon which the girders were end launched. It is incidentally of interest to note the contrast of types in the illustration. The truss spans in the near bridge are light pin-connected railway spans removed from the bridge at Ste. Rose, P.Q., already mentioned, the middle structure is of English riveted lattice truss spans, built about 1880, and the bridge in the background is a light pin-connected highway structure, of about the year 1900.

Although size, weight and erection difficulties generally preclude the use of long plate girder spans for highway bridges, there have been some notable exceptions to the rule. The main highway between Toronto and Montreal now crosses the Ottawa river over two large deck plate girder bridges separated by Ile Perrot. The westerly bridge, built in 1924, contains, in its 17 spans, 7 spans 101 ft. long, while the easterly one, built somewhat later, contains 11 plate girder spans and 3 truss spans. For the plate girder spans no stringers were used, the floor slabs resting on floorbeams cantilevered over the main girders and spaced at 5 ft. centres. Both structures were designed by L. V. Denis, A.M.E.I.C., of the Department of Public Works of Canada.

Another notable highway bridge utilizing deck plate girder spans is the Champlain bridge (Fig. 2) over the Ottawa river, at Ottawa, built under the direction of A. K. Hay, A.M.E.I.C., in 1929. Of the 26 spans, 4 are 125 ft. long and 12 ft. deep, with bottom flanges sloping near the ends. The superstructure was fabricated and erected by the Dominion Bridge Company, Ltd.

Extensive use of the simple plate girder type of bridge has been made in grade separation structures. By reason of the ever pressing problem of reducing the distance from base of rail, or finished roadway, to the underside of the superstructure to an absolute minimum, much attention has been given to the design of shallow floor systems. In the early years of the present century considerable numbers of grade separation bridges were built without stringers, but with closely spaced transverse floorbeams of rolled I-sections with concrete filling between and a concrete deck over them on which the ballast and trackage were placed. The soffits of the floorbeams were left exposed. Examples of this type of construction are to be seen in the grade separation structures along the C.P.R. line through North Toronto. In the case of the Mountain street and Guy street grade separation bridges of the Canadian National Railways, at Montreal, built in 1931, with closely spaced floorbeams and no stringers, the steel below the sidewalk level was given a 2-in. gunite coating over mesh reinforcement.

**Fig. 5—C.P.R. Viaduct at Lethbridge, Alta.**
**Longest and highest viaduct in Canada. 1909.**

**Fig. 6—Original C.N.R. Bridge over the St. Lawrence at Coteau, Que. 1889.**
**Early example of fully riveted work. Thirteen out of seventeen spans erected by flotation.**

A variation of this type was developed in accordance with which closely spaced I-beam stringers, encased and covered as in the type above mentioned, were used. These stringers were supported at the middle of the highway by a bent parallel to the highway and composed of deep and heavy plate girders supported by H-section columns. On account of the depth of the girders no bracing was found to be necessary in the plane of the bent. Examples of this type are to be seen in the Kenilworth avenue subway, Hamilton, built in 1915, and in the grade separation structures over Bloor street west, Toronto, built in 1925.

An important development in the plate girder type of grade separation bridge is seen in the use of reinforced concrete T-beam construction for stringers and slab with transverse floorbeams of structural steel. Several such structures have been built in the Central Region of the Canadian National Railways, of which C. P. Disney is bridge engineer, as, for example, the subways at Breslau, Ont. (Fig. 3), Shannonville, Ont. and Charlesbourg Road, P.Q. A very important feature of these structures is that the rails rest directly on the concrete deck except for interposing steel chairs, oak cushions, or rubber cushions. The total depth of the floor construction is by this means greatly reduced, with an important resultant economy for the whole work.

A number of ingenious features are contained in the Vidal street grade separation bridge over the C.N.R. at Sarnia, built in 1932, and utilizing Canadian-rolled steel only. The floor framing consists of transverse floor beams, stringers heading into these floorbeams and 6-in. secondary I-beams running transverse'y across the tops of the stringers

**Fig. 7—Erection of the C.P.R. Bridge over the French River.**
**Span end-launched across the river in three hours. 1907.**

and carrying ¼-in. deck plates welded to their top flanges. To the top surface of the plates grids were welded and in and over these an asphaltic floor surfacing was laid. Both the main floorbeams and the transverse 6-in. beams were designed to utilize the floor plates as flange section, thus constituting an application of the battledeck type of construction. The 72-ft. centre span of the main supporting girders of the bridge is of the cantilever type, with a 48.5 ft. suspended span. Temperature changes are accommodated in the supporting bents by fixing the columns at the bottom and allowing them to bend. This constitutes a treatment

**Fig. 8—C.P.R. Bridge over the St. Lawrence, Lachine, Que.**
**The two through spans were end-launched over the previously constructed deck structure. 1913.**

**Fig. 9—C.P.R. Bridge, Saskatchewan River, Nipawin, Sask.**
**Highway deck enters on a Y carried by brackets from railway bents. 1932.**

**Fig. 10—Highway Viaduct at Eastern Entrance to Hamilton, Ont.**
**Typical steel truss and tower viaduct on Ontario provincial highway. 1921.**

similar to that given the approach viaducts of the Hawkesbury bridge, over the Ottawa river, and the Canadian approach of the Detroit-Windsor bridge. The superstructure was designed and erected by the Sarnia Bridge Company, Ltd.

### Plate Girder Viaducts

For many years one of the most important uses of plate girders has been in the construction of steel viaducts. The wide and deep valleys of Canada invite crossing by structures of this type.

At the beginning of the half century period under review, numbers of tall steel railway viaducts were being built. These were generally of the deck type with noisy, pin-connected rod bracing that would not be tolerated today. Several of them were built for the C.P.R. near Toronto, on the Toronto-Montreal line.

In the Don Valley, a C.P.R. viaduct, known as the "Half-Mile Bridge," was built in 1888 and, forty years later, due to the added demands of traffic, was replaced, under the direction of P. B. Motley, M.E.I.C., engineer of bridges for the railway, in a manner calculated to excite the admiration of all bridge engineers, as well as laymen. Concrete piers were built without disturbing the existing steel towers and, between trains, plate girder spans 112.25 ft. long, riveted up complete and field painted, weighing 105 tons, were dropped into place by a single derrick, as shown in Fig. 4. The between-train task of the Canadian Bridge Company, Ltd., was to remove four plate girder spans and the tops of three bents, to run out and drop the new span into place, and erect and connect up the deck and rails. This was done with a maximum time from each breaking of track to the restoration of traffic of two and one half hours.

Incidental to the construction of the National Transcontinental Railway, now incorporated in the Canadian National Railways, a number of important steel viaducts were built. One of the most interesting of these is the Cap Rouge viaduct, some three miles west of the Quebec bridge, erected in 1906, by the Dominion Bridge Company, Ltd. It is distinctive in that the transverse bracing of the bents is of the stiff diagonal type without horizontal struts. A significant fact is that in spite of certain advantages that may be claimed for the bracing system it has not been widely adopted.

The longest steel viaduct on the National Transcontinental Railway is the Little Salmon River viaduct in New Brunswick, built in 1910. It has a length of 3,918 ft. and a height of 200 ft., with late girder spans of the half-through type. Horizontal struts with diagonals designed for tension only were used in this structure.

The longest and highest steel viaduct in Canada, and apparently the most massive one in the world, is the justly famous Lethbridge viaduct, which carries C.P.R. trains over the Belly river. This structure, 5,328 ft. long and 314 ft. high from river bed to base of rail, was built under the direction of the C.P.R. bridge engineer, then C. N. Monsarrat, M.E.I.C., and was fabricated and erected by the Canadian Bridge Company, Ltd., in 1909. Partly to safeguard the structure against serious damage due to derailments and partly for the psychological benefit to the traveller, the construction is of the through type. Tower spans are 67.1 ft. and intermediate spans 98.8 ft. The transverse bracing of the bents is of the conventional type, and while both the transverse and longitudinal systems are stiff they are figured for tension only. The manner of erection is indicated generally in Fig. 5.

**Fig. 11—Yonge Boulevard Bridge, near Toronto.**
**Heavy Warren truss structure on reinforced concrete H-piers. 1928.**

Many steel viaducts have been constructed by utilizing, in whole or in part, truss spans supported by either steel towers or concrete piers, or arch spans on a concrete substructure. Such bridges will be discussed under the superstructure type predominating in the bridge.

### Simple Truss Spans

Fifty years ago the employment of multiple intersection trusses was much more frequent than it is to-day. The deck spans of the C.P.R. bridge built over the St. Lawrence at Lachine were, therefore, not unnaturally of this type. In highway bridge practice the use of the double intersection Warren truss persisted for some time. For

**Fig. 12—Bayview Avenue Bridge, Toronto.**
Three lines of stringers with cantilevered end panels of end truss spans. 1929.

**Fig. 13—Burrard Bridge, Vancouver, B.C.**
An instance of the successful collaboration of engineer and architect. 1932.

example, the two 370.9-ft. spans of the highway bridge built at Richmond, P.Q., in 1903, were of this form. Nowadays, Pratt or single intersection Warren trusses, subdivided if need be, are commonly employed. The use of very long parallel chord trusses, such as were used in the Richmond bridge, is less frequent. For through construction, sloping top chords are often employed for spans as short as 150 ft.

Pin-connected trusses, with their rattling eyebars, counters and rod laterals, have long since given way to stiff riveted structures, except for the very longest spans. A record was established with the construction of the Richmond bridge in that the 370.9-ft. spans continued for many years to be the longest riveted highway spans in existence. When European fabricators, who never succumbed to the American fondness for the pin-connected type, furnished superstructures for Canadian crossings they were always provided with riveted connections.

A number of important simple truss span railway bridges were completed in the late eighties and early nineties. Amongst these may be mentioned the International bridge of the C.P.R., with 240-ft. fixed spans having curved top chords, at Sault Ste Marie, in 1889; the Fredericton bridge over the St. John River, in 1887; the C.P.R. bridge over the Portneuf river, P.Q., in 1890; and the Grand Narrows bridge, Cape Breton, about 1890.

Especially noteworthy was the construction of the well known railway bridge over the St. Lawrence river, at Coteau, P.Q., built in 1889. This structure, composed chiefly of 217-ft. double intersection Warren truss spans with sloping top chords, as shown in Fig. 6, was riveted throughout, a distinct departure for Canadian-fabricated work at that time. A mass-production type of erection was adopted, in that thirteen of the seventeen spans were assembled, riveted up completely, and stored on trestles from which they were taken off by barges and floated into position on their piers. The erection of the superstructure, carried out by the Dominion Bridge Company, Ltd., was probably the most rapid piece of work of its kind that had been performed up to that time. The Coteau bridge and the Grand Narrows, C.B., bridge were amongst the first bridges in Canada to be erected in this manner. Due to increasing live load the whole superstructure was renewed in 1910 and the erection done in very much the same manner as for the original bridge.

A very extensive piece of work involving simple truss spans was the rebuilding of the Victoria bridge over the St. Lawrence, at Montreal, in 1898, during which the 25 tubular spans were replaced by an equal number of simple Pratt truss spans. The old piers, built in the late fifties, had only to be extended a short distance up stream. The truss spans were erected around the old tubular spans with only slight disturbance to the traffic, this being possible by ingenious special construction at the tops of the piers.

Difficult erection problems involving simple truss spans were met admirably in floating into place the spans of the Northwest and Southwest Miramichi river bridges of the Intercolonial Railway, in 1901, and of the Shubenacadie river bridge, N.S., in 1903.

A special constructional feature exists in the simple truss combined railway and highway bridge across the Fraser river, at New Westminster, B.C., built in 1903, according to the design of Waddell and Harrington. The northerly span is a spread or Y-span, and although only 225 ft. in length is 19 ft. wide at the river end and 135.5 ft. wide at the shore end. This arrangement was necessitated by the bifurcation of the railway.

One of the cleverest erection procedures that has ever been carried out in this country was the erection of the C.P.R. bridge across the French river, in 1907, by the Canadian Bridge Company, Ltd. The main span is 412.7 ft. in length and riveted throughout. It is one of the longest

**Fig. 14—Reinforcement of C.P.R. Stoney Creek Arch, B.C.**
Stresses in new and old arch trusses equalized by weighting and special details. 1929.

**Fig. 15—Highway Arch at Saint John, N.B.**
**Erected as 3-hinged arch and transformed to 2-hinged condition. 1915.**

riveted railway spans ever built and at the time of construction was the largest and heaviest single track fixed span yet completed in Canada or ever erected by the end launching method. Moreover, it is believed that the record still stands. The forward end of the structure was carried on a scow, as shown in Fig. 7, and the rear end slid on greased rails. The load was transferred to the scow by a 155-ft. steel truss span designed for the Wanapitae crossing, and the heavy span was pulled forward by a hoisting engine utilizing as the pulling links a string of bottom laterals borrowed from the 250-ft. span designed for the Pickerel river crossing a short distance away. Once all the material and equipment, borrowed or otherwise, was assembled, the span was moved across the river in only three hours. C. N. Monsarrat was the engineer of bridges for the Railway.

Another ingenious method of erection was that for a 200-ft. C.P.R. truss span at Kenora, built about 1907. In the process of double tracking, the span had to be placed alongside an existing span. No falsework being possible in the river, suspended needle beams from each of the floorbeams of the old span were installed and stringers and rails were laid on these to form a skidway. Each truss was assembled separately on shore and hauled across the opening, after which it was jacked sideways and lowered into position on its bearings.

Replacement of the old continuous bridge of the C.P.R. across the St. Lawrence at Lachine, in 1913, was characterized by a particularly bold erection procedure for the two 408-ft. through spans. In double-tracking the line the railway bridge department, of which P. B. Motley was, and continues to be, the head, found that the most practicable plan was to construct two independent single-track bridges on the one set of piers, as shown in Fig. 8. The channel spans, weighing 1,300 tons each, were erected on the adjacent deck spans and were then end-launched into their final positions, the forward end of each span being carried on a specially constructed scow and the rear end on an ingenious truck or buggy. To avoid overstressing the side spans a special distributing frame was devised by F. P. Shearwood, M.E.I.C., whereby a three-point bearing with equal reactions was produced at the rear end of the span. So accurately was the work organized by the Dominion Bridge Company, Ltd., who fabricated and erected this structure, as well as its predecessor, that it was possible by signalling the operator of the hauling engine 800 ft. away to spot the forward end of the moving span on its exact final location.

An important aspect of the work of the railway bridge engineer is to utilize to the full the service life of structures. A characteristic example of this was the installation, in the C.P.R. bridge over the South Saskatchewan, at Outlook, of eight 240-ft. multiple intersection deck truss spans removed from the Lachine bridge.

In the Nipawin bridge of the C.P.R. (Fig. 9), erected over the Saskatchewan river, in 1932, the accommodation of highway traffic was provided for on a lower deck by the device of carrying the roadway along a part of the approach railway viaduct on brackets cantilevered from one side of the steel bents. The arrangement is essentially a Y, and similar to the one employed for the railway approach of the Fraser river bridge at New Westminster, B.C., already mentioned. To avoid foundation uncertainties the truss spans were made as long as could be erected by cantilevering the full length without introducing special erection features of high cost. Temporary harness was employed by the Dominion Bridge Company, Ltd., for deepening the trusses over the piers.

In highway bridge practice, the use of pony spans with T-chords for lengths greater than 100 ft. has been abandoned, and this type of chord is rarely seen now except for

**Fig. 16—Prince Edward Viaduct, Toronto.**
**Crescent-shape 3-hinged arches designed for double deck. 1918.**

**Fig. 17—Hingeless Steel Arch Bridge, Paris, Ont.**
**Economical skew structure with I-beam rib segments. 1931.**

Fig. 18—Tied Highway Arch, Ormstown, Que.
Visibility improved by omission of diagonals. 1935.

the shortest spans. One cause of this is the disappearance of the unsightly wing, or outrigger, type of bracing for the top chord, which persisted until the use of the 1922 Specification for Steel Highway bridges of the Canadian Engineering Standards Association became generally recognized. Lateral support of the chord is now generally provided by stiff verticals capable of withstanding a large moment without much deflection.

An important development in steel highway bridge construction was the substitution of reinforced concrete floors for timber floors. The first structure of this kind with a concrete floor built in Canada appears to have been that built at Thornhill, near Toronto, in 1903. It was a 35-ft. span with a reinforced concrete slab deck carrying paving brick surfacing. The following year Musson's bridge with a 124-ft. span was built near Weston, Ont., with the same type of deck. The credit for this innovation belongs to James McDougall, then engineer for the County of York.

The end-launching method of erection on high viaducts was employed with conspicuous success in the building of the Twelve Mile creek and the Sixteen Mile creek bridges on the Dundas Highway, between Toronto and Hamilton, in the years 1917 and 1921. The superstructures of these bridges were built of old 108-ft. Intercolonial Railway iron lattice girders, which had already put in one life time in the railway service, thereby justifying the confidence that had been reposed in them by Sandford Fleming. Norman McLeod, alert contractor for the Dundas Highway bridges, unearthed the girders and brought about their installation for another life time in the highway service. Triangular pilot trusses were bolted to the forward ends of each girder span, which had been riveted up completely with its bracing. The whole span was then hauled forward into position, the pilot trusses serving as guides and coming in contact with the forward pier before the permanent trusses became overbalanced.

Much steel viaduct work involving the use of deck truss spans has been carried out in the neighbourhood of Toronto in the last fifteen years. In this category might be mentioned the Rouge river bridge, completed in 1920, by the Ontario Department of Highways, of which A. B. Crealock, M.E.I.C., was then bridge engineer. This structure, on a 5 per cent grade, was characterized by marked economy in both steel and masonry. The tower columns were somewhat novel for that time, of H-section, and the floorbeams heavy rolled Bethlehem beams.

The easterly entrance to Hamilton of No. 2 highway from Toronto contains two economical viaducts, of a type similar to that at the Rouge river, one of which is shown in Fig. 10. Both viaducts were fabricated and erected by the Hamilton Bridge Company, Ltd.

A particularly massive viaduct combining deck Warren trusses and reinforced concrete piers is the Yonge Boulevard bridge, constructed in 1928, by the Ontario Department of Highways, and erected and fabricated by the Canadian Bridge Company, Ltd. As will be seen from Fig. 11, this structure utilizes reinforced concrete piers of H-section similar to those adopted by Frank Barber for the East York-Leaside viaduct built the previous year.

The Bayview avenue bridge, Toronto, built to the design of Margison and Babcock, in 1929, is characterized by novel features in the form of the supporting reinforced concrete towers, as will be seen from Fig. 12, and by marked economy in the steel superstructure. Only three lines of stringers were used and the end steel spans were cantilevered out one panel to meet the abutment at one end and the concrete approach at the other. The Dominion Bridge Company, Ltd., erected the steel.

In steel truss viaduct work mention should be made of the Englehart bridge built over the White river on the Ferguson highway, in 1932, utilizing Canadian steel

Fig. 19—Alexandra Cantilever Bridge, Ottawa.
Anchor arms erected on floating falsework. 1900.

**Fig. 20—Quebec Cantilever Bridge.**
**The world's longest cantilever span. First use of K-trusses. 1917.**

throughout, the sections being built up satisfactorily of plates and angles.

A feature of interest in connection with the design of the Perley bridge over the Ottawa river at Hawkesbury, was the notable economy in the approach viaduct structure. As many as six spans in series are without longitudinal bracing, the columns having been designed with fixed bases and allowed to take the calculated bending. This structure, built under the direction of the Dominion Department of Public Works, of which K. M. Cameron, M.E.I.C., is chief engineer, was erected by the Canadian Bridge Company, Ltd., in 1931.

As an example of the attractiveness that is possible with deck truss span steel bridges the Burrard bridge over False creek, Vancouver, might be cited. This was constructed in 1932 under the direction of J. R. Grant. M.E.I.C. On account of the especially prominent location of the bridge, architectural collaboration was sought, with the excellent result evident from Fig. 13. The main piers, extending above the roadway as pylons, were made particularly massive and connected across the roadway by decorated galleries.

### Arch Spans

In the replacement of timber bridges on the C.P.R. in British Columbia, the steel arch was early adopted as a particularly suitable form of structure. A 336-ft., 3-hinged, latticed-rib arch, replacing a long span Howe truss structure carried on timber towers, was erected over Stoney Creek in 1893, in accordance with the design of that gifted engineer, H. E. Vautelet, M.E.I.C. The steel arch was built around the old timber structure without interruption of traffic, the loads being applied to the rib at every third panel point along the haunches and four panels apart adjacent to the crown. For this reason the stringers were very long, in fact, truss spans in themselves.

Spectacular reinforcement of this early arch was carried out in 1929 according to the general plans of the railway bridge engineer by the Canadian Bridge Company, Ltd. New arch trusses were erected outside of the old ones, equalizers were inserted connecting the adjacent trusses and on them the transverse bents carrying the track spans rested, as shown in Fig. 14. The new arch trusses were weighted to deflect equally with the old under their proper dead load, and connection was then made between the new and the old trusses, so that the entirely new floor system and the live load could be carried equally by the new and old ribs.

Displacing the Edward Serrell suspension bridge, built in 1852, a 2-hinged, spandrel-braced arch, designed by C. C. Schneider, was erected over the Reversible Falls, at Saint John, N.B., in 1915, by the Dominion Bridge Company, Ltd. This structure, shown in Fig. 15, has a span of 565 ft. and a rise ratio of 1 in 9.2, which is next in order of flatness to the short span of the Peace bridge between Fort Erie and Buffalo. The arch ribs were erected as cantilevers and connected up to a temporary crown hinge, thus making the structure 3-hinged for a large part of the dead load. Subsequently, by the insertion of an accurately fitted piece in the top chord, the arch was made 2-hinged for the remainder of the dead load, for live load and for temperature changes.

The Niagara river, particularly the gorge below the Falls, has been an attractive location for steel arch bridges. In 1897, the Grand Trunk Railway replaced the Roebling suspension bridge by a 2-hinged, spandrel-braced arch span of 550 ft., which was heavily reinforced for intensified traffic in 1919. Farther up, at the site of the old Samuel

**Fig. 21—C.P.R. Cantilever, Saint John, N.B.**
**Novel through truss form with horizontal top chord. 1921.**

Keefer suspension bridge, the 840-ft. Niagara Falls and Clifton arch was erected in 1898, holding the record of span length for arches until displaced by the Hell Gate arch at New York, in 1917. The 640-ft. Michigan Central Railroad arch at Niagara Falls was erected in 1924 in the same manner as the Saint John arch, in that the structure was made 3-hinged for most of the dead load and 2-hinged for all subsequent loads. The floor system consists of independent plate girder spans for each panel, thereby eliminating the participation of the floor system in the arch rib stresses and obviating much uncertainty in the behaviour of the structure as a whole. The most recent of the Niagara river bridges, the Peace bridge between Fort Erie and Buffalo, erected in 1927, contains a series of 3-hinged, solid-ribbed arches. The shortest of the spans, next the Canadian shore, has a rise ratio of only 1 in 11.3, the smallest rise ratio of any steel arch in this country.

Typical of double-deck arch construction is the Prince Edward viaduct over the Don river on Bloor street, Toronto, shown in Fig. 16. This structure, built in 1918, according to the design of the late Thomas Taylor, M.E.I.C., and erected and fabricated by the Hamilton Bridge Company, Ltd., is of the 3-hinged type, with the hinges in the top chord. The crescent form of arch rib grew out of the provision for a lower deck to accommodate subway trains, should they ever have to be operated over the structure.

Hingeless steel arches are sufficiently rare in Canada to merit special mention. An important structure of this type (Fig. 17) was built over the Grand river, at Paris, in 1931, according to the design of Arthur Sedgwick, bridge engineer for the Ontario Department of Highways. The arches are not only hingeless but are on a skew, which naturally complicated the work of detail and fabrication. The whole work was completed, however, at the very low price of about $6 per sq. ft. of floor surface. Another novel feature was the use of 36-in. rolled I-beams as rib segments.

Improved visibility was secured with the attractive 140-ft. tied steel arch (Fig. 18) built at Ormstown, P.Q., in 1935, by the Dominion Bridge Company, Ltd. Absence of diagonals confers upon the structure some of the simplicity of the commonly occurring reinforced concrete tied arch.

**Fig. 22—Montreal—South Shore Cantilever.**
**Riveted structure employing silicon steel extensively. 1929.**

### Cantilever Spans

Although an important cantilever bridge had been built for the C.P.R. over the Reversible Falls, at Saint John, N.B., in 1885, the type was infrequently employed in Canada for some time subsequently. In the year 1900, however, the Alexandra, or Interprovincial, bridge (Fig. 19) was erected over the Ottawa river, at Ottawa, under the general direction of Guy C. Dunn. The main span is 555.75 ft. Frazil ice troubles complicated the work of erection, carried out by the Dominion Bridge Company, Ltd. The plan followed was to erect the anchor arms on falsework carried on distributing Howe trusses to floating scows which were towed as a unit from one erection position to another. The cantilever arms and suspended span were erected to a junction at the centre by the ordinary cantilever method.

The high-water mark of achievement in cantilever bridge construction for Canada, as for the whole world, was reached with the completion of the Quebec bridge, in 1917. While its central span of 1,800 ft. does not greatly exceed the two main spans of the Forth bridge, the live load for which it was designed was 2¼ times that for the older structure. The suspended span, 640 ft. in length, continues to hold the record for Canada for a simple truss span. Many novel features characterize the structure, the most important of which is the K-arrangement of diagonals in the main trusses, proposed by Phelps Johnson. In contrast with the Forth bridge, the trusses were made parallel rather than battered, thus giving simpler detail and facilitating erection. The Board of Engineers under whose direction the structure was finally completed consisted of C. N. Monsarrat (Chairman), Ralph Modjeski and C. C. Schneider. The St. Lawrence Bridge Company, whose design for the superstructure was adopted by the Board, fabricated and erected the structure. Figure 20 shows the completed bridge.

**Fig. 23—High Level Cantilever Bridge, Hamilton, Ont.**
**Artistic short-span cantilever simulating an arch. 1932.**

Consequent upon increasing traffic demands, the light pin-connected cantilever of 1885 at Saint John, N.B. was replaced by the C.P.R. in 1921, under the direction of P. B. Motley, engineer of bridges. As will be seen from Fig. 21, it is totally unlike the old cantilever, seen in the background. An unusual feature for a through bridge is the horizontal top chord for both cantilever arms and suspended span. Another, is that it is riveted throughout. The main span, 450 ft. in length, was erected by cantilevering from both ends to a junction at the centre. The contractor for the steel was the Dominion Bridge Company, Ltd.

The most modern of the large cantilevers is the Jacques Cartier bridge between Montreal and the South Shore, completed in 1929, under the direction of Monsarrat and Pratley. It has a central span of 1,097 ft., and is fully riveted, except at the top and bottom of the main vertical posts over the piers.

Fig. 24—Kettle Rapids Continuous Bridge, Hudson Bay Railway. Most important existing continuous bridge in Canada. 1917.

Profiting by favourable experience with the Quebec bridge in respect of erection and deformation, the K-system of trussing was adopted. Silicon steel was employed in all main truss members, in flanges of the floorbeams and of a number of stringers, and in the main material of most of the bottom lateral system. Elsewhere, a special carbon steel was used. As will be seen from Fig. 22, the varying length of the panels for the cantilever arms resulted in a pleasing general outline. The Dominion Bridge Company, Ltd. fabricated and erected the steel.

Short span cantilevers, simulating arches, may often be employed advantageously in steel, as in reinforced concrete. Such a one is the highway bridge over the Desjardins Canal, Hamilton (Fig. 23), built in 1932, under the direction of James, Proctor and Redfern, Ltd. It has a central span of 220 ft. and a suspended span of only 55 ft. To lighten the suspended span and the cantilever arms the flooring was made of haydite concrete. Particular attention was given to the architectural features of the design, with the result that the bridge was awarded honourable mention by the American Institute of Steel Construction for bridges in its class in the 1932 competition. The general contractor was E. P. Muntz, Ltd., the contractor for the steel work being the Hamilton Bridge Company, Ltd.

### Continuous Spans

In conformity with the North American neglect of the continuous type of bridge, there have until recently been few steel bridges of this type built. Given foundations that do not yield appreciably, there are distinctive advantages in continuity. Cantilever erection, with little or no addition of material for erection stresses, reduction of positive moments, lessening of deflection, narrowing of piers and simplification of bearings outweigh the additional difficulties of design.

For many years the continuous spans of the St. Lawrence River railway bridge at Lachine, P.Q., built in 1886, to the design of C. Shaler Smith, remained the most outstanding example in America, if not in the world, of the continuous type. This structure contained four spans in a continuous series, the two central 408-ft. spans being of through construction and joined up cleverly to the deck side spans. As has already been mentioned, this notable structure was replaced in 1913 by the present C.P.R. bridge.

The marked advantages of the continuous type where cantilever erection is imperative were exemplified in the Hudson Bay Railway bridge over the Nelson river, at Kettle Rapids (Fig. 24). This structure, designed by W. Chase Thomson, M.E.I.C., and fabricated and erected by the Canadian Bridge Co., Ltd., was completed in 1917. It is composed of three fully riveted subdivided Warren truss spans of 300, 400 and 300 ft. in length. All material for the north end of the bridge had to be transported across the river by cableway, the middle span being cantilevered each way to closure at the centre.

The three-span continuous bridge, shown in Fig. 25, was erected over the Saguenay river, at Kenogami, in 1922,

Fig. 25—Saguenay River Continuous Bridge at Kenogami. Economical structure with low piers. 1922.

by the Eastern Canada Steel and Iron Works, Ltd., for Price Bros. and Company, Ltd. It is of the double-intersection Warren type with trussed legs, which markedly reduce the height of the piers.

A continuous structure was also found best for the crossing of the Chibougamau Railway over the Saguenay river. Three spans of 190, 270 and 190 ft. were found best suited to the crossing by the engineers, Monsarrat and Pratley. The structure was erected in 1929 by the Dominion Bridge Company, Ltd.

An unsymmetrical structure of two continuous spans was designed and built by the Dominion Bridge Company, Ltd., in 1930 for the Shawinigan Power Company, over the St. Maurice river, at Rapide Blanc, about 28 miles north of La Tuque, P.Q. The 260-ft. span was erected by cantilevering it full length, using the 78-ft. span as an anchor arm. The appropriate reaction for the normal weight of steel was produced at the forward end by adjustment, and the stresses for the remaining load were calculated as for a continuous structure of two spans.

Suggestive of the European "dinosaur" type is the main span (Fig. 26) of the Honoré Mercier bridge over the St. Lawrence river, a short distance below the C.P.R.

Fig. 26—Honore Mercier Bridge, Lachine, Que. Contains a unique continuous tied arch span. 1934.

bridge. This important structure was completed in 1934, under the direction of O. O. Lefebvre, M.E.I.C., chief engineer, with W. Chase Thomson M.E.I.C., as structural engineer, the Dominion Bridge Company, Ltd., fabricating and erecting the steel work. The main span is a 400-ft. continuous through tied arch, a type unique in Canada. Splayed truss spans connect the northerly span of the continuous unit to the simple span portion of the bridge, and the latter to a possible future vertical lift span at the proposed deepened St. Lawrence waterway channel close to the North shore. The reinforced concrete viaduct on the South shore was built with the use of light structural steel Kane trusses as reinforcement, which at the same time carried the weight of the forms and of the green concrete. All steel used in the structure was rolled in Canada.

A notable recent development in continuous construction is the use of welded plate girder spans. The six continuous all-welded 107-ft. deck plate girder spans over the Ste. Anne river at La Perade, P.Q., built in 1936, form the most outstanding example of this kind of work yet carried out in North America. Minimum depth is provided at span centres, as shown in Fig. 27, with a pleasing arch profile between piers. An apparent saving in weight of 27 per cent, compared with simple span riveted girders, was effected, according to the Dominion Bridge Company, Ltd., who built it. L. F. Gaboury was the engineer for the owners.

### Suspension Spans

Despite its manifest merits, the suspension type of bridge has not been widely adopted in Canada. Apart from the three frontier suspension bridges over the Niagara river—the Roebling bridge which stood on the site of the present C.N.R. arch from 1855 to 1897, the Samuel Keefer bridge on the site of the Niagara Falls and Clifton arch (1868-1898), and the Queenston-Lewiston bridge (1851-1864 and 1899 to the present), the only other important suspension bridge built before 1887 was the Edward Serrell bridge at Saint John, N.B. (1852-1915).

Appreciating the advantages of the suspension type of highway structures, Frank Barber built three such structures in York County, near Toronto, between 1910 and 1920, with spans varying from 90 to 150 ft., one of them having a reinforced concrete floor.

A light suspension bridge of 451 ft. span employing 2.5-in. locked coil cables and wooden towers was built across the Bulkley River canyon, at Hagwilget, B.C. in 1913. Proving too light, the structure was replaced by a heavier one of the same general type, in 1931. The 1.5-in. wire ropes employed for the cables—nineteen in each—were prestressed at the site, using a weight box suspended in a pit and filled with gravel. The process was repeated three times for each rope, and when the actual dead load was applied in the structure the cable sag came to within ½ in. of the calculated sag. The structure was designed by the Department of Public Works of British Columbia, of which Patrick Philip, M.E.I.C., was Deputy Minister and chief engineer at the time.

Canada has an important professional, as well as economic, interest in the Ambassador suspension bridge between Windsor and Detroit, completed in 1929. Its main span of 1,850 ft. was the longest suspension span and the longest highway span in existence at the time of completion. The cables, of the unloaded backstay type, are now of cold-drawn wire, replacing the heat treated wire which developed alarming breakages under partial dead load near the point of tangency with the strand shoes, both in this structure and that at Mount Hope, R.I. Silicon steel was used in the towers and in the chords of the stiffening trusses, which have a depth of only 1/84 of the span, the smallest depth ratio used in any important suspension bridge up to the time of building. The approach viaduct on the Canadian side, fabricated and erected by the Canadian Bridge Company, Ltd., has very little longitudinal bracing. The columns, like those for the Hawkesbury bridge, were figured to bend longitudinally.

In recent years, the use of a group of twisted wire ropes, rather than parallel wires, for suspension bridge cables has greatly extended. An important example of this kind of construction is that shown in Fig. 28, the Grand'-Mère bridge over the St. Maurice river, built in 1929. Robinson and Steinman and Monsarrat and Pratley were the engineers, and the Canadian Bridge Company, Ltd., the contractor for the steel. The structure is of the unloaded backstay type, with a central span of 948.8 ft. Taking advantage of the severity of the Canadian winters, rather than being hampered by it, the cables and stiffening trusses were erected from the ice, the cable ropes having been prestressed at the mills to 60,000 lb. per sq. in. and then slacked to 20,000 lb. per sq. in., at which they were measured and marked. The towers are pivoted at the base, the shoe castings being finished convex downward and bearing on base casings finished with a level surface.

The most recent of the large Canadian suspension bridges is that over the North branch of the St. Lawrence river to the Island of O leans (Fig. 29), completed in 1935, for which the main span is 1,059 ft. The two cables, each 10 in. diameter, are composed of 37 prestressed twisted wire ropes, 1⅜ in. in diameter. The structure was designed by the deflection theory of stress analysis by Monsarrat

Fig. 27—Welded Continuous Plate Girder Bridge, La Perade, Que.
Most important all-welded bridge in Canada. 1936.

Fig. 28—St. Maurice River Suspension Bridge, Grand'Mere, Que.
Twisted wire rope cables. Cables and stiffening trusses erected from the ice 1929.

**Fig. 29—Island of Orleans Suspension Bridge.**
**Wire rope cables, fixed-base towers and welded pedestals and saddles. 1935.**

and Pratley, the engineers for the suspended part of the bridge. The towers, which are of Chromador steel, are of the flexible type, with fixed base, both pedestals and saddles being built up of steel plates welded together and stress-relieved. The contractor for the steel work was the Dominion Bridge Company, Ltd.

### Movable Spans

Movable spans of any importance in Canada have almost wholly consisted of the swing, bascule or vertical lift types.

At its completion in 1887, the 234.75-ft. "Menomonee" swing span over the Lachine canal on the north approach to the St. Lawrence river railway bridge at Lachine was deemed by its designer, C. Shaler Smith, to be the latest word in movable bridges. In elevation, it was of the shape of a deep isosceles triangle, the low position of the top chords at the ends being intended to reduce the wind resistance to turning.

In 1915 this old structure was replaced by a deck plate girder swing 239.6 ft. long, operating on the old pivot pier, as shown in Fig. 30. The utilization of this pier for a double track structure of the type selected—the longest span of the kind in existence—was justly regarded as a remarkable achievement. Four main girders, 13.5 ft. deep at the centre, were used, as it was essential to maintain traffic during the replacement. The work was done under the general direction of P. B. Motley by the Dominion Bridge Company, Ltd.

In the meantime, in 1896, an important bobtailed swing span had been erected over the Burlington channel, near Hamilton, Ont. in conformity with the design of H. E. Vautelet. At that time it was the only bridge in Ontario to be operated electrically, with the exception of the one at Sault Ste. Marie. It was a pin-connected, rim-bearing structure, actuated by a sprocket on the land arm travelling along a fixed chain. The bridge has since been replaced by the present twin Strauss bascule spans, erected in 1922 and 1931 by the Hamilton Bridge Company, Ltd., and resting on a rest pier between the two channels.

Many bascule spans of the multiple-trunnion type have been erected in Canada during the past fifty years. The C.P.R. bridge over the Kaministiquia river at Fort William, erected in 1913, is a good example of a heavy bridge of this type. It is a single-leaf, double-deck Strauss with a clear span of 200 ft. At the time of its construction this structure held the size record for a double-deck bascule. Another sizable Strauss is the 160-ft. Cataraqui river bridge, Kingston, erected in 1917 by the Hamilton Bridge Company, Ltd. The main trunnions were placed above the level of the roadway, thereby making them freer from dirt and more accessible for greasing.

**Fig. 30—C.P.R. Swing Bridge over Lachine Canal.**
**Longest deck plate girder swing span in existence. 1915.**

An example of the rolling lft type of movable bridge is the 114-ft. single-leaf, four-track Scherzer erected in 1913 for the C.P.R. over the McKellar river, at Fort William. Bridge No. 1, over the Welland Ship canal, at Port Weller (Fig. 31), is a 93.6-ft. rolling lift span designed by Harrington, Howard and Ash. Altogether, there are seven rolling lift bridges over the canal.

Of late years there has been a strong disposition to simplify bascule bridge design by reverting to the original simple trunnion idea. Three recent structures of this kind are the 80-ft. single-leaf Norwood street bridge, Winnipeg, built in 1931, to the design of A. J. Taunton, M.E.I.C., Department of Public Works of Canada; the 90-ft. double-leaf bridge at Gaspé, P.Q., designed by Baulne and Leonard, and built in 1932; and the 165-ft. double-leaf structures at Sorel, P.Q. (Fig. 32), built in 1932, to the design of the Department of Public Works of Quebec, with Monsarrat and Pratley as consulting engineers. These structures were fabricated and erected by the Dominion Bridge Company, Ltd.

Vertical lift bridges are by no means new in Canada. One was built at Shubenacadie, N.S., in 1899, but up to 1914, few others had been built. In that year the Canadian Northern Pacific Railway bridge over the North Thompson river, at Kamloops, B.C., was erected, containing a 93-ft. Waddell and Harrington vertical lift span. The vertical tower legs stand on the piers and the rear or battered legs, stand on the side plate girder spans. The lift is operated by a gas engine.

**Fig. 31—Rolling Lift Bascule, Welland Ship Canal.**
**Simple modern type for moderate spans. 1929.**

A simple vertical lift of Strauss design is the Pretoria avenue bridge at Ottawa, built in 1916. As the lift is only 20 ft., a system of levers was profitably substituted for cables.

Of the eleven vertical lift bridges over the Welland Ship canal, the 209-ft. structure at Allanburg (Fig. 33) may be taken as a representative example. To lighten the dead load, the floor was made of haydite concrete. The design is that of Harrington, Howard and Ash.

An undertaking of especial difficulty, involving the installation of a vertical lift span, was the reconstruction of the Second Narrows bridge at Vancouver, B.C., in 1935. According to the plans of Monsarrat and Pratley, who were in charge of the work, a new lift span had to be inserted where the old wrecked 300-ft. span had been, substituting a clear waterway of 272 ft. for one of 175 ft. The old bascule span was cut down by two panels and made fixed, the counterweight being left in position, as shown in Fig. 34. For the new lift span the counterweight ropes were prestressed, thus making it possible to dispense with equalizers. Chromador, a chrome-copper-silicon steel, was extensively employed. The contractor for the superstructure was the Dominion Bridge Company, Ltd.

### CONCRETE SUPERSTRUCTURES

As a material for bridge superstructures, concrete made no appreciable impression on Canadian engineers until about 1907. Very properly, they proceeded with caution. In consequence of this attitude, only two concrete bridges had been built on the provincial highway system of Ontario up to the end of 1923, although much work in this material had been done in the municipalities. In the following year, however, the province built ten bridges of moderate size of this material. In Manitoba, numbers of concrete spans up to 30 ft. in length had been built prior to 1915. As the war proceeded, steel for bridge construction became scarcer and dearer, and longer and longer spans of concrete appeared in the form of through and tied arches. When, by 1920, all material and labour had risen about equally in price, steel resumed something of its old place in the construction of the longer spans. Concrete was slow to arrive in Saskatchewan. Up to 1919, practically all important highway bridge construction had been in the form of standard steel spans on pile bents. The railways throughout the country were still more cautious in applying concrete to bridge work.

Employment of concrete for the main superstructure elements of bridges may be in the form of simple beams or girders, viaducts, untied arches, tied arches, rigid frames, cantilevers or continuous spans.

#### Simple Beam and Girder Spans

In 1907 James McDougall designed and built a 50-ft. through girder span for highway use at Unionville, Ont. About the same time James A. Bell began to build girder spans in Western Ontario, so that in a few years there were a great many examples of them to be seen. No attempt has been made to rival the 142-ft. girder spans of the Salt river bridge, in California, but frequent and appropriate use is made of the girder type for highway bridges in those parts of Canada where the snowfall is not excessive. Mani-

**Fig. 32—Double-Leaf, Simple Trunnion Bascule, Sorel, Que.**
**Characteristic example of modern simple trunnion design. 1932.**

**Fig. 33—Vertical Lift Bridge, Welland Ship Canal, Allanburg.**
**Typical of the eleven vertical lift bridges over the canal. 1929.**

**Fig. 34—Reconstructed Second Narrows Bridge, Vancouver, B.C.**
**Prestressed counterweight ropes used without equalizers. Chromador steel extensively employed. 1935.**

toba found that through girders acted as collecting troughs for snow, and had to abandon them.

The railways have found simple reinforced concrete beams and slabs of great value in grade separation structures. For example, the Ontario street subway under the C.P.R. tracks, at Montreal, was built in 1924 by placing precast slabs 6.5 by 3.1 by 23.25 ft. on precast reinforced concrete columns, using a locomotive crane. The work, which was done under the direction of L. J. Leroux, A.M.E.I.C., was carried out with trifling disturbance to traffic.

Typical of the practice of the Central Region of the C.N.R. is the poured-in-place slab subway at St. Lambert, P.Q., built in 1931, with a depth of 4 ft. and a clear span of 49.4 ft. As the rails were fastened directly to the slab without ties or ballast, and with nothing more than an oak cushioning strip embedded in the concrete, the depth from base of rail to underside of the superstructure is scarcely more than the slab depth.

The use of reinforced concrete beams and girders in viaduct and continuous construction is now extensive and will be discussed separately under these headings.

### Viaducts

A comparatively early use of concrete for railway viaduct construction was in the Weston road viaduct of the C.P.R. at West Toronto, built in 1911. It was of the now familiar beam and slab type.

Two viaducts of much bolder construction were erected in the C.P.R. between Toronto and Leaside Junction, in 1918. One of these, shown in Fig. 35, is over the abandoned belt line railway, and the other over Reservoir Park. Precast T-beam units 6.5 ft. wide, 4.7 ft. deep and 35 to 37 ft. long, weighing up to 55 tons were placed by a wrecking crane on the caps of reinforced concrete bents cast in place. Up to that time no reinforced concrete beams of greater length than 25 ft. had been employed for railway bridges. As will be seen from the illustration, the lateral and longitudinal bracing consists of staggered horizontal struts, haunched top and bottom.

The merits of the flat slab system were utilized in the construction of the Fourth Avenue viaduct, Moose Jaw, Sask., in 1929, by C. A. P. Turner. Columns were spaced at 30 ft. centres and the reinforcement was arranged in accordance with that engineer's well-known mushroom pattern.

### Arches Without Ties

Most of the early activity in concrete bridge construction centred upon the arch. The first arch of considerable size erected in Canada appears to have been the 92-ft. earth-filled one at Massey, Ont. (Fig. 36), built in 1906 under the direction of W. A. McLean, M.E.I.C., then

**Fig. 35—C.P.R. Reinforced Concrete Viaduct, Toronto.**
**Precast T-beam units weighing 55 tons placed by wrecking crane. 1918.**

**Fig. 36—Reinforced Concrete Highway Arch, Massey, Ont.**
**A 30-year old long-span highway arch. 1906.**

Fig. 37—University Bridge, Saskatoon, Sask.
Largest concrete bridge undertaken in Canada up to 1916. 1916.

chief engineer of the Ontario Department of Highways. In the Lyndhurst bridge at St. Thomas, built in 1908, by James A. Bell, the span record was raised to 116 ft. Two years later, Barber and Young built the 118.5 ft. Wadsworth arch at Weston, Ont., probably the first open spandrel reinforced concrete arch in Canada. In 1913 Frank Barber constructed the King George arch on the Middle road, over the Sixteen Mile creek, near Oakville, Ont., with a span of 135 ft. This structure, as good as new, was blown out in 1935 to make way for the much wider and higher bridge necessitated by rebuilding the road as a first-class highway.

Fig. 38—Centre Street Bridge, Calgary, Alta.
Artistic double-deck skew structure. 1918.

Fig. 39—Ashburnham Bridge, Peterborough.
Longest concrete arch span and first use of temporary hinges in Canada. 1921.

The University bridge over the South Saskatchewan river, at Saskatoon, was the most extensive piece of reinforced concrete construction undertaken in Canada up to the date of its completion in 1916. As is seen from Fig. 37, it consists of ten open spandrel arch spans, four of which are 150 feet. in the clear. On account of the extreme severity of the winter in Saskatchewan, the arch rings were left for summer work. The temperature stresses in the rings of certain of the arches exceed all other stresses combined. D. B. Luten was the consulting engineer to the Board of Highway Commissioners, under which the bridge was constructed.

At almost the same time the very attractive Centre street bridge in Calgary (Fig. 38) was completed. It is a double-deck skew structure containing, amongst others, three spans of 150 ft. John F. Greene was responsible for the design.

One of the outstanding concrete bridges of Canada for structural and architectural merit is the Ashburnham bridge at Peterborough, completed in 1921, to the design of Frank Barber. This structure, shown in Fig. 39, contains a clear span of 234 ft., the longest span in Canada. For aesthetic reasons secondary spandrel arches were used, decreasing in span towards the crown of the main arch, and above these the structure was cinder filled. Temporary hinges were used at the skewbacks and at the crown for the first time in Canada. There is no reinforcing in the main arch ribs except that for the hinges, the analysis indicating no possibility of tension.

Another structure of attractive appearance is the bridge at Elora, Ont., built according to the plans of A. W. Connor, M.E.I.C., in 1921, and shown in Fig. 40. Two 80-ft. spans meet on an 80-ft. stone masonry pier that had served the lifetime of the steel bridge displaced by the concrete arches. The trusses of the old bridge were used to support the forms for the concrete ribs which came outside the trusses. To supplement the capacity of the trusses, the forms for the ribs were built to act as arches, the lateral rods from the old bridge serving as ties.

Knox bridge, over the Montreal aqueduct, built in 1926, was constructed with Mesnager temporary hinges at the skewbacks and crown of the three arch spans, the notches being left open for thirty days after the completion of the deck and ninety days after the ribs were placed. J. F. Brett, A.M.E.I.C., was the designing engineer.

Not often has the three-hinged type been employed for reinforced concrete arches in Canada, but the Ahuntsic bridge, over the Back river, near Montreal, shown in Fig. 41, is an important instance. This structure, built in 1930, under the direction of L. J. Leroux, by the Dufresne Construction Company, Ltd., contains five spans, the longest of which is 222 ft. The hinges are steel castings abutting on centre pins at the rib axis. A very unusual feature, which apparently worked, is that the arch ribs were not placed in voussoirs, but each half rib was concreted fully in one operation, thereby saving the trouble of symmetrical pouring. The centring was kept in place until the deck structure was concreted.

Very careful thought was given to the design of the Wellington ravine arch bridge, Edmonton, Alta., by the consulting engineer, Professor I. F. Morrison. The ribs of the main span are much shallower than they are wide, in conformity with the modern effort to reduce temperature and deformational stresses. Floorbeams are closely spaced and there are no stringers. Provision was made against sideways bending of the ribs due to lateral temperature effects by inserting single lines of 60-lb. rails near each vertical face. The structure was completed in 1932.

The Broadway bridge at Saskatoon, Fig. 42, like its mate, the University bridge, is a large and important structure. It contains five arches of varying span and six girder spans, the maximum arch span being 201 ft., centre to centre of piers. The arches have approximately the same rise ratio and wide, shallow ribs. No reliance was placed by Dean C. J. Mackenzie, M.E.I.C., the engineer in charge, on possible deck participation, as the deck was poured after the falsework had been removed. On the other hand, the temperature moments and thrusts at the springing were arbitrarily increased about 75 to 150 per cent, respectively. To reduce spandrel post flexural stresses, some of the posts were hinged. The expansion of the approach viaduct was looked after by flexure in the slender columns, and the position of the columns on the shifting south bank was secured by a line of reinforced concrete struts extending downhill to the first main pier. The structure was completed in 1932, as an unemployment relief project.

**Fig. 40—Twin Arches on 80-ft. Masonry Pier, Elora, Ont.**
**Trusses of old bridge supported forms which were built as a tied arch. 1921.**

Another instance of a three-hinged reinforced concrete arch is the 66-ft. pipe line bridge built over an inlet to Esquimalt harbour, in 1928. Brass-bushed steel pins turning in steel castings were used at the springings and crown. Each half rib was cast on the flat and erected by derrick.

Three similar multiple-span arch bridges were built in the years 1934-1936 at the crossings of the Middle Road over the Credit river, Sixteen Mile creek and Twelve Mile creek, under the direction of Arthur Sedgwick, bridge

**Fig. 41—Ahuntsic Bridge, Back River, near Montreal.**
**Important instance of 3-hinged reinforced concrete arch construction. 1930.**

**Fig. 42—Broadway Bridge, Saskatoon, Sask.**
**Shorter spandrel posts hinged and expansion of approach viaduct looked after by column bending. 1932.**

engineer for the Ontario Department of Highways. The Twelve Mile creek bridge is shown in Fig. 43. The maximum arch span in any of them is 145 ft. and they are all characterized by wide shallow ribs. Internal vibration of concrete was carried out for the last two bridges, completed in 1936.

### Tied Arches

Recognizing the advantages of the reinforced concrete arch but being frequently unable to build the regular type because of low available rise, engineers in Canada, following the lead of Considère, set about to adapt the arch to crossings where low banks existed by using a horizontal tie, thus transforming it into a bowstring truss.

The first reinforced concrete truss bridge built in Canada was the 80-ft. Middle road bridge across the Etobicoke river, near Long Branch, Ont., constructed in 1909 by Barber and Young. As will be seen from Fig. 44, diagonals were used to stiffen the compression chord against distortion, the chord then being proportioned for area and not for moment of inertia. In order to reduce the probability of cracking in the concrete of the bottom chord, the steel reinforcement in it was prestressed. Bond of the concrete between the work of one day and that of the next was promoted by placing cracked ice in bags on the work when stopping at night. The material was then found to be plastic on the resumption of work next morning. This structure was removed in 1932 to give way to a much wider bridge for the newly rebuilt Middle road.

The first pure bowstring truss span, or tied arch, constructed of concrete in Canada was that at Riverview, Man., built in 1917, under the direction of P. Burke Gaffney. The span, 86.5 ft., was the longest of any tied arch in America at that time.

**Fig. 43—Twelve Mile Creek Bridge near Bronte, Ont.**
**Typical of three recent arch bridges on the newly rebuilt Middle Road. 1936.**

As an incident to the construction of the concrete highway between Toronto and Hamilton, four tied arches were built in 1918-1919 at Mimico creek, Etobicoke river, Credit river and Twelve Mile creek, all of them except the one at Mimico creek, being 119.1 ft. in clear span. Splices in the bottom chord were provided by staggered turnbuckles, the rods being attached by nuts to anchor plates at the ends. These bridges were built in accordance with the designs of F. G. Engholm, and proved to be eminently satisfactory. Due to the widening of the highway, the structures at Mimico creek and the Etobicoke river have recently been removed, but were found to be in excellent condition, never having required any expenditure for maintenance. Figure 45 shows the bridge at the Credit river, which is still standing.

Favourable experience with the tied arch type has brought about its application to bridges containing many

**Fig. 44—Middle Road Concrete Truss Bridge, Etobicoke River.**
**First use of the type in Canada. Tension chord steel prestressed. 1909.**

spans. One at Freeport, Ont., built in 1925, under the direction of A. B. Crealock, bridge engineer for the Ontario Department of Highways, has seven tied arch spans, 71.75 ft. centre to centre of piers. Floorbeams and hangers were spaced 6.2 ft. apart and no stringers were employed. A 9-span structure, with spans of 72.6 ft., was built at Caledonia, Ont. in 1927 under the same auspices. This bridge is shown in Fig. 46. A similar structure with five

82.2-ft. spans was built at Bridgeport, Ont., in 1934, by D. J. Emrey, A.M.E.I.C.

An interesting detail in connection with some of the tied arches recently built by A. B. Crealock, as at Belleville, Ont. and Galt, Ont., is the use of precast splash panels suspended in the plane of the hangers with a view to preventing the splashing of pedestrians on the sidewalks and making it impossible for children to dart out on the roadway from behind the hangers.

A tied arch with very unusual features was erected across the Montreal aqueduct at Du Bois street in 1930, to the design of J. F. Brett. It is 146 ft. in span from centre to centre of piers and the top chord is cantilevered at each end 13 ft. over the piers. As indicated in Fig. 47, there is no top bracing. To facilitate simple arch action the hangers were made as flexible as possible in the plane of the rib. Each of these ribs has a dumb-bell cross section, each bulb of the dumb-bell being heavily reinforced as a spiralled compression member. The rocker bearings consist of transverse steel flats between two heavy steel billets and temperature effects are provided for by allowing the piers to rock on thin sand cushions between the bottom of the pier and the top of its footing. All long steel reinforcement was spliced by welding.

As is recounted in a special paper presented to the Institute on the occasion of the present celebration, Dean C. J. Mackenzie has recently designed and supervised the construction of a three-span tied arch structure at Borden, Sask., containing a centre span 213 ft., centre to centre of piers, the longest on this continent.

### Rigid Frames

The credit for introducing to Canada the reinforced concrete rigid frame, which is really only an arch with a sudden change of rib alignment at the knees, belongs to the Ontario Department of Highways, of which Arthur Sedgwick is bridge engineer. Three such structures of single span and one of two spans were built under the auspices of the Department of Essex county, in 1931. Another one with three spans of 50 ft. was built in the same year over the Scugog river, near Lindsay, Ont. Since that time all concrete structures with spans of 20 to 60 ft. have been designed by the Department according to this type wherever it was applicable. The impetus thus given the rigid frame construction has resulted in the building of about forty such highway bridges in varicus parts of the province of Ontario during the past six years.

One of the important recent rigid frame bridges is the structure built in 1935 over the Etobicoke river, near Toronto, on Highway No. 2, in accordance with the design of the Ontario Department of Highways. This bridge, shown in Fig. 48, contains two 75-ft. spans, the maximum spans so far built by the Department. Whereas all of its previous rigid frame bridges were of the solid type, the Etobicoke river structure is of the thin, multiple-rib type, giving a very small quantity of concrete, but requiring a considerable quantity of closely grouped steel at the compression faces of the ribs. This is the first example of the rib type of rigid frame in Canada.

About 1931 the Central Region of the C.N.R. began building 2-span rigid frame structures for carrying highways over the railway right of way. These had a very shallow depth in the centre span and, due to the omission of abutment wing walls, have a small yardage of concrete.

A novel application of the rigid frame type of a 2-span structure for railway use is found in the C.N.R. crossing over St. Clair avenue, W., Toronto. This bridge, built in 1931, rests freely on a centre pier and has a total depth from base of rail to soffit of only 4.33 ft. The rails rest on shallow concrete ties placed directly on the deck slab without the employment of ballast. The structure is shown in Fig. 49.

As an example of long span railway rigid frame construction, the grade separation bridge of the C.N.R., shown in Fig. 50, over Petite Cote road, near Vaudreuil, P.Q., built in 1933, may be cited. This structure has a clear span of 72.7 ft. and was built in two parallel units, in order that traffic might be diverted to one while the other was being constructed. Incidentally, the bridge being on a skew, the stress situation was definitely simplified and helped by the use of two parallel structures.

**Fig. 45—Tied Highway Arch, Credit River, Ont.**
Typical of four bridges built on Toronto-Hamilton highway (No. 2) 1917-1919.

**Fig. 46—Multiple Span Tied Arch Bridge, Caledonia, Ont.**
Similar structures at Freeport and Bridgeport, Ont. 1927.

**Fig. 47—Dubois St. Bridge over Montreal Aqueduct.**
Dumb-bell type of spirally-reinforced compression chord. Piers rock on sand cushions. 1930.

**Fig. 49—C.N.R. Two-Span Rigid Frame, St. Clair Ave. West, Toronto.**
Rests freely on centre pier. Shallow concrete ties and no ballast used. 1931.

### Cantilever Spans

The frequently arising desire to utilize an arched structure in reinforced concrete, in spite of unsatisfactory foundation conditions, may be met in many cases by the construction of a cantilever bridge of this material. Reactions are vertical and moderate settlement of the piers or abutments will not produce any particular harm.

An early use of the cantilever principle is found in the Mount Pleasant road bridge, Toronto, built in 1918, in accordance with the design of J. S. Burgoyne, now engineer of railways and bridges for Toronto. The bridge looks in elevation like a 3-span arch structure, but is in reality two single span rigid frames with the rib of each projecting over the inner pier to a free joint at the centre of the middle span. At this joint the steel reinforcement was allowed to project from the concrete at one side of the gap into the concrete at the other side, bond being prevented by wrapped tar paper.

An application of the cantilever principle similar to that followed in the construction of the Mount Pleasant bridge was made in the Assiniboine Park bridge, Winnipeg, built in 1932. It is composed of three units of 172 ft. with a free expansion joint at mid-length of every third span, the maximum spans being 86 ft.

Designed in 1930, and built in 1933, the Cockshutt bridge near Brantford represents an important example of pure cantilever construction in reinforced concrete. The bridge contains three spans of 113 ft., two of 99 ft., and two shore cantilever spans of 40.2 ft. Two of the 113-ft. spans are cut and contain suspended spans 65.7 ft. in length. Provision was made for longitudinal movement at piers by carrying the reactions into a pier through heavily reinforced concrete rockers 5.7 ft. deep and operating in a recess in the top of the pier. The reactions of the main girders are transmitted by means of inverted corbels, through long, hard lead plates placed transversely to the direction of the bridge. The structure was built under the direction of R. M. Lee and F. P. Adams, A.M.E.I.C., with C. R. Young, M.E.I.C., as the designing engineer for the substructure. It is shown in Fig. 51.

### Continuous Spans

A unique form of continuous construction is seen in the Governor's bridge built at Toronto, in 1923, in accordance with the design of F. G. Engholm, A.M.E.I.C., and shown in Fig. 52. The main span, 200 ft. in the clear, was designed to act partly as the centre span of a continuous unit and partly as an arch. Very heavy tensile reinforcement, consisting of 2½-in. round rods with welded splices, is inserted at the top of the main supporting ribs. Transverse floorbeams are used, but no stringers, the space between the floor framing and the soffit of the arched structure being hollow.

One of the most important of the continuous bridges in reinforced concrete is that built at Lambton, Ont., in 1928, to the design of Frank Barber. It is of the continuous beam type, comprising three units of three spans each and one unit of two spans. The spans vary from 56 ft. to 84 ft. By reason of continuity and the use of a square floor panel reinforced both ways the design proved to be very economical.

**Fig. 48—Two-Span Rigid Frame, Etobicoke River.**
First use of multiple-rib type in Canada. 1935.

**Fig. 50—C.N.R. Rigid Frame, Vaudreuil, Que.**
Heavy long-span grade separation structure. 1933.

An application of the continuous type to grade separation structures was made in the building of the Yonge street subway, Toronto, in 1929. The structure is 80 ft. in the clear between abutments with a centre row of columns along the axis of Yonge street. A slab depth of only 4.33 ft. was required.

Cast-in-place continuous construction for grade separation work is also well illustrated by the Richmond street subway at London, built by the C.N.R. in 1931. Like the St. Clair avenue subway, there is no integral connection of the superstructure to the centre pier. Precast reinforced concrete ties were employed to give greater flexibility for track changes.

Of great convenience to traffic is the plan of erecting precast slabs on cast-in-place abutments and a centre pier by the use of wrecking cranes. Such a structure is the one built near St. George, Ont., in 1932, and shown in Fig. 53. This slab was dropped in place by two cranes between trains. Extreme shallowness of the floor was made possible by placing the rails directly on the slab. Similar construction was adopted for the St. Francois street subway in Sherbrooke, P.Q., which was erected in twenty minutes between trains.

### TIMBER SUPERSTRUCTURES

It may not be generally known that considerable use of timber for bridge superstructures still persists in Canada. In Quebec covered timber bridges are still being built. Rather remarkably, the government of New Brunswick found, in 1919, that the neglect of maintenance of steel bridges was playing such havoc with them that it reverted to wooden superstructures for spans up to 180 ft. Wood was still plentiful and of good quality in the province.

With the comparatively recent development of timber connectors the application of timber to important bridge construction has revived. An instance of this is seen in the 210 ft. span of the Sioux Narrows bridge, Ont., built in 1935, as shown in Fig. 54. The life of the timber for this structure was considerably lengthened by creosoting. Another creosoted timber bridge is that at Quesnel, B.C., consisting of five through Howe truss spans, three of which are 180 ft. in length.

Where timber of sufficient dimensions and satisfactory quality can be obtained locally, it may prove economically practicable in many cases to construct timber bridges of substantial span lengths, but this will not be the case where timber must be brought very great distances at high expense.

### SUBSTRUCTURES

Engineers in Canada, as elsewhere, have learned from long, and sometimes bitter, experience the need for adequate exploration of the material upon which substructures are to rest. One of the most striking of these mishaps was the collapse of two spans of the bridge across the St. Lawrence at Cornwall, in 1898. The pier common to the two spans had been founded on what appeared to be a satisfactory bed of hardpan, but unfortunately this bed was only 2 ft. thick. When the erection load had reached a certain stage, the pier punched through the thin layer of hardpan and quickly sank 15 ft. into the soft clay beneath.

#### Pile Foundations

During the pioneer stage of bridge building in Canada it was natural to construct substructures by the driving of pile bents. Many fairly important steel bridges in the west were carried in this way. Apart from the shortness of life of piling timber at levels that are alternately wet and dry, there is always the risk of long piles being pushed sideways by the weight of the superincumbent earth filling. Several instances of damages to bridge superstructures have arisen from the lateral displacement of piles.

As a means of transmitting loads from piers or abutments to solid material beneath, piles still continue to serve an important role. During the last twenty-five years, however, there has been an increasing disposition to use concrete piles, either cast-in-place or precast and driven in the same way as wooden piles. The permanence of such piles makes it possible to seat the footings at a much higher level than would be possible with timber piles.

#### Open Caissons

Fifty years ago the art of employing open caissons for bridge foundations had been well established. They had been successfully used in the construction of the Intercolonial Railway bridges in the early seventies and in the St. Lawrence river bridge at Lachine, in 1886. It was consequently well-tested practice to employ this method in the construction of the piers of the Coteau bridge over the St. Lawrence, in 1888. Improved manipulation of the caissons for this structure was devised by towing the caissons out between barges, and on the anchoring of the latter in the proper position, weighting the caisson and letting it down to its position on the bottom by means of tackle on the decks of the barges.

**Fig. 51—Cockshutt Cantilever Bridge near Brantford, Ont.**
**Expansion by reinforced concrete rockers in pier recesses. 1933.**

In sinking the bottomless caissons through the ice in water as deep as 57 ft. for the foundations of the Alexandra cantilever bridge at Ottawa, in 1898, eight to twenty feet of sawdust, slabs and water-logged timbers were encountered. Despite the difficulty of removing such material the caissons were finally seated at their proper level and on being cleared out by divers the concrete was placed under water to a point 20 ft. below water level.

Reinforced concrete open caissons with removable bottoms were successfully employed in the construction of the foundations for the Welland Ship Canal bridges. The caisson was landed on the cut-off piles by flotation, the timber bottoms were removed and the caisson then partly filled with concrete placed underwater. It was then unwatered and the remainder of the concrete placed in the dry.

#### Pneumatic Caissons

Increased certainty and safety in manipulating pneumatic caissons has developed in Canada in the last twenty-five or thirty years. For example, in the pneumatic caisson work for the Quebec bridge, in which the caissons were carried down to a depth of over 100 ft. below high water level, there were no lives lost and only a few cases of illness resulting from working under air.

In the construction of the Honoré Mercier bridge over the St. Lawrence at Lachine, in 1933, a number of improvements in foundation construction by the pneumatic method were introduced. Welded steel caissons were adopted, new methods were devised for guiding and sinking the caissons and forming breakwaters, and a specially designed deflector was used in combination with a powerful shear-leg boat.

#### Combination Methods

Very frequently the inevitable variation in foundation conditions from pier to pier requires differentiation of foundation procedures.

**Fig. 52—Governor's Bridge, Toronto.**
Combined continuous frame and arch structure. Hollow spandrels and piers. 1923.

**Fig. 53—C.N.R. Precast Slab Bridge, St. George, Ont.**
Placed between trains. Rails rest directly on slab. 1932.

For example, in the reconstruction of the C.P.R. bridge over the St. Lawrence at Lachine, in 1912, all piers but the seven in the deepest water were built in open cofferdams with puddled walls. For the seven piers where the depth of water was from 20 to 27 ft. the work was done by a combined pneumatic and open process. In order to reduce the current from 8 to 12 miles an hour to about 2 or 3 miles an hour, wing rock-filled cribs were constructed at 45 deg. immediately up stream on each side of the old piers. The caissons were built in place on pontoons and, when ready, the latter were allowed to fill with water and were then pulled out from under the caisson as it settled.

In the case of the Jacques Cartier bridge at Montreal the foundation work included open crib, pneumatic caisson and pile foundations. Similarly, in the construction of the two new piers for the Second Narrows bridge, at Vancouver, one was built by the open caisson method and the other by the pneumatic method.

The foundations for the tower piers of the Detroit-Windsor bridge were each composed of two cylindrical reinforced concrete open caissons carried to 105 ft. below water level. In accordance with the plan of operation the caissons were sunk part of the way by open dredging and were then converted into pneumatic caissons and the sinking finished under air.

### Substructure Materials

Although up to about 1900 the use of concrete as an above water material for piers and abutments was not prevalent, some engineers were beginning to advocate its more extensive use. Dr. Martin Murphy, M.E.I.C., for many years provincial government engineer for Nova Scotia, was a pioneer in concrete construction, and many of his structures were of this material. Although concrete had first been employed in highway bridge construction in Nova Scotia, somewhat hesitatingly in 1883, by 1888 it was being used widely and with confidence.

The matter was examined with particular care in the Maritime Provinces by reason of the great disruption of masonry structures across tidal waters, in the vertical zone subjected to alternate exposure and submersion by the tides. It was found, however, that good concrete did not behave any worse than stone masonry, although as an extra precaution the piers of certain structures, as for example the Annapolis-Granville bridge, were sheathed with hardwood for that portion of the height within the tidal range.

Practice generally requires the use of stone masonry facing for those portions of important bridge substructures subjected to direct ice action, as for example in the piers of the two St. Lawrence bridges at Lachine, the Jacques Cartier bridge, and the Detroit-Windsor bridge.

### Substructure Forms

Forms of piers have naturally changed greatly during the past fifty years, as a result of the effort to cut down weight and cost. Suggested, no doubt, by the old twin-cylinder piers filled with concrete, which had some vogue many years ago, piers have taken on the dumb-bell or H-form. Instances of this form are to be found in the East York-Leaside viaduct piers and those for the Yonge boulevard bridge, already mentioned. A web continuously connected to the two flanges of the pier was used in these cases, but in many cases, such as for the Mercier bridge over the St. Lawrence, and the Galipeault bridge over the Ottawa between Ste. Anne and Ile Perrot, the connection of these flanges is not made continuous. In other words, the pier under lateral load is, in effect, a Vierendeel girder.

**Fig. 54—Creosoted Timber Bridge, Sioux Narrows, Ont.**
Long span truss construction with timber connectors. 1935.

# Authors of Semicentennial Papers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A. Duperron


The Hon. C. D. Howe


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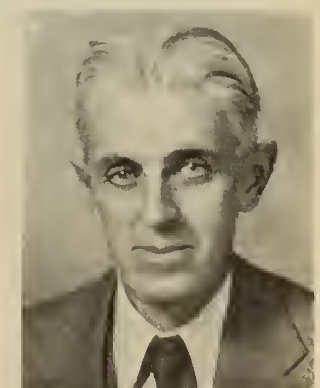
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THE ENGINEERING JOURNAL

VOLUME XX, No. 7 JULY, 1937

# Investigations of Canadian Coals Including Their Testing, Classification and Utilization*

## Conducted by the Staff of the Division of Fuels, Department of Mines and Resources, Ottawa.

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*Chief of Division, Division of Fuels, Bureau of Mines*
*and*
*R. E. Gilmore, M.E.I.C.,*
*Senior Engineer, Division of Fuels, Bureau of Mines.*

**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

In this paper the nature, scope and summary results of recent investigations involving testing, classification and utilization of Canadian coals conducted by technical officers of the Division of Fuels of the Department of Mines and Resources are considered briefly. For those readers desiring more complete details regarding certain investigations or phases of investigations, references to various reports are given at the conclusion.

While not indicated the paper is divided into two parts or sections. The first section, in addition to a few introductory paragraphs on Canadian coal resources and production, deals with the smaller laboratory scale chemical and physical tests employed by fuel technologists together with a discussion of the significance and relative importance of these tests. This section also briefly summarizes the laboratory investigations of friability, size stability, and grindability of coal conducted at the Fuel Research Laboratories, and illustrates the application to Canadian coals of the rank, grade, and use classification specifications recently promoted by the American Society for Testing Materials, in whose classification activities representatives from Canada had a prominent part.

The second section of the paper reviews the recent large scale investigations conducted by officers of the Fuels Division, at the Fuel Research Laboratories, at collieries, and at by-product coke oven plants. These investigations comprise coal seam survey work, physical and chemical analysis survey of screened sizes of coal from Canadian collieries, washing, sizing and storage investigations, combustion tests in an experimental domestic furnace—hand, blower and stoker fired, pulverized fuel tests, briquetting, coking tests at high, low and medium temperatures, and high pressure hydrogenation tests. The objective of these investigations, in which a few coals from Great Britain and the United States have been included for comparative purposes, has been to obtain results that will serve for a more efficient and greater utilization of Canadian coals.

In preparing this paper the aim of the authors has been to present a comprehensive review of recent investigations for prospective readers and particularly for engineers, generally and specifically interested in fuel technology.

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### Coal Production

Canada's coal resources[1]† are confined almost entirely in the extreme eastern and western provinces: in Nova Scotia and New Brunswick in the east and in British Columbia, Alberta and Saskatchewan in the west. Accordingly it is in these provinces that the producing mines are located, leaving the central provinces of Quebec, Ontario and Manitoba dependent on coal mined outside their borders. In Manitoba and Ontario appreciable deposits of lignite have been located but their production is relatively negligible.

The total Canadian coal production in 1935 was nearly fourteen million short tons. Of this total approximately forty-two per cent was mined in Nova Scotia, thirty-nine per cent in Alberta, ten per cent in British Columbia and seven and two per cent from Saskatchewan and New Brunswick respectively. Nearly ninety-six per cent of the coal mined in Canada is consumed in the country, but the production represents only about fifty-five per cent of the total consumption, consequently nearly one-half of our coal requirements are imported.

The trend of the production, importation, and consumption of coal in Canada[2] may be gathered from perusal of Table I covering the ten-year period from 1926 to 1935.

Table I

Production, Exports, Imports and Consumption of Coal in Canada—Millions of Short Tons

| Year | Production | Exports | Imports | | Consumption |
|---|---|---|---|---|---|
| | | | Bituminous | Anthracite | |
| 1926 | 16.5 | 1.03 | 12.4 | 4.2 | 31.6 |
| 1927 | 17.4 | 1.11 | 14.6 | 4.1 | 34.1 |
| 1928 | 17.6 | 0.86 | 13.4 | 3.7 | 33 0 |
| 1929 | 17.5 | 0.84 | 14.2 | 4.0 | 34.1 |
| 1930 | 14.9 | 0.62 | 14.5 | 4.3 | 32.5 |
| 1931 | 12.2 | 0.36 | 9.9 | 3.2 | 24.5 |
| 1932 | 11.7 | 0.28 | 8.8 | 3.1 | 22.9 |
| 1933 | 11.9 | 0.26 | 8.2 | 3.0 | 22.3 |
| 1934 | 13.8 | 0.31 | 9.4 | 3.5 | 25.9 |
| 1935 | 13.9 | 0.42 | 8.6 | 3.4 | 25.0 |

†References to the bibliography at the end of the paper are indicated by superscript numbers thus [1].

The production for 1935 according to province, area and kinds of coal mined is shown in detail in Table IV, a summary of which is as follows:—

| | |
|---|---|
| *Bituminous coal* | |
| Nova Scotia | 5,808,420 tons |
| New Brunswick | 342,333 tons |
| Alberta | 2,248,685 tons |
| British Columbia | 1,329,379 tons |
| Yukon | 825 tons |
| *Sub-bituminous (and lignite) coal* | |
| Manitoba | 3,984 tons |
| Saskatchewan | 919,477 tons |
| Alberta | 2,645,917 tons |

*Coking and Non-coking Coals*

Most bituminous coals since they cake and form coke when burned are said to be coking coals whereas the high rank anthracites and the lower rank sub-bituminous coals are non-coking. The terms "hard" and "soft" which referred originally in this country to Pennsylvania anthracite and to ordinary bituminous steam coal respectively, are now more or less obsolete since it is generally realized that there are hard and soft varieties of both of these kinds of coal. The term coking as used here is general rather than specific and refers to all those coals that have poor, fair, and good coking properties as judged by the "coke" button residue obtained in proximate analyses.

Of the total reserves in Canada only about seven per cent belong to the bituminous coking coal class. The remaining ninety-three per cent belong to the non-coking classes of which less than one-half of one per cent is anthracite. This implies that approximately 92.5 per cent of the country's resources are non-coking, sub-bituminous and lignite coals. Of the total production of coal over three-quarters is bituminous, and it is likely that this ratio of coking to non-coking coals will continue for several decades. When, therefore, the supply of the higher rank coals nears exhaustion practically all of the country's coal resources will consist of the lower rank non-coking coals.

The coal mined in the Maritime provinces is almost entirely bituminous, the geological age of which is known as carboniferous. In British Columbia also, practically all the coal is bituminous but its geological age and characteristics are different to those in the east and moreover vary widely among themselves. In Alberta, where all classes of coals are produced, about one-half of the coal mined is coking bituminous coal, the other half comprising the non-coking varieties. In this province certain of the non-coking coals, on account of their free burning properties, freedom from smoke, etc., find extensive use for household heating, and for this reason are known as domestic coals. They also find extensive use for steam raising, for which the cost in comparison with other suitable coals available is the deciding factor. The coal mined in Saskatchewan is lignite which is also the designation of the coal deposits recently discovered in Northern Ontario.

## Chemical and Physical Laboratory Analyses

The analyses of Canadian coals have been reported from time to time in Department of Mines publications [3,4] These are what are ordinarily known as chemical analyses and are to be considered separate from, or rather supplementary to, physical tests to which a coal should be subjected in order to ascertain its relative suitability for a given use. A laboratory chemical analysis is conducted on the finely divided pulverized coal, whereas most of the physical tests are carried out on the sized coal sampled at any stage on its course from the producer to the consumer. At this point it may be emphasized that for the proper interpretation of the chemical analysis of a coal for commercial use, its general physical characteristics should be known. Furthermore it should be remembered that the "as received" basis on which analyses are reported means as received at the laboratory, and does not allow for changes in respect to moisture, calorific value, etc., that may have taken place in the transit of the sample to the laboratory.

*Proximate and Ultimate Analyses*

As is generally known the proximate analysis comprises determinations for moisture, ash, and volatile matter contents, with the fixed carbon percentage obtained by difference; and the ultimate analysis includes determinations of carbon, hydrogen, ash, sulphur, nitrogen, and oxygen by difference. The ash content in both analyses is assumed to be the same, and when the only item of the ultimate analysis called for is the sulphur content, it is a usual laboratory practice to report it separately from the four items of the proximate analysis. In the proximate analysis the sulphur is assumed to be equally distributed between the volatile matter and the fixed carbon. A complete analysis of a coal, or other solid fuel, includes calorific value, the results of which are usually expressed as B.t.u. per pound.

All of these determinations are chemical when judged by the criterion that a chemical change takes place, but strictly speaking most of them are physical-chemical in nature. Other chemical determinations are the fusion point of ash (F.P.A.) and the analysis of the ash involving determinations for part of all of the following elements, viz., silica, iron, aluminum, calcium, magnesium, sodium, potassium, titanium, phosphorus, and sulphur, all of which are usually reported as oxides. Additional tests are often necessary to ascertain general caking or coking, potential smoke producing and storage properties.

*Physical Analyses*

Determinations of the physical properties of coal, coke or other solid fuels include a screen analysis for size, specific gravity—true and apparent, bulk density for weight per cubic foot and cubic feet per ton, friability or its complement size stability, and grindability or pulverizability. These determinations as mentioned above are made on the fuel either in the lump form or after being either crushed or pulverized. The preparation of the sample for laboratory analysis is physical rather than chemical and involves crushing, riffling, and pulverization according to standardized laboratory procedure. Sampling which also may be classed as physical is a very important item as a pre-requisite to analysis in the laboratory. The importance of sampling will be evident when it is realized that it is subject to greater errors than the subsequent analysis.

The theory of sampling is, that in the final pulverized laboratory sample amounting generally to less than one-half pound each particle represents a lump, before or after crushing, of the original lot of fuel sampled. Hence when a single laboratory sample is to represent quantities as large as a railway carlot or a steamship cargo, great care is necessary in the sampling procedure. According to good sampling practice, the original gross sample should be an aliquot portion of the lot sampled, and as the gross sample is reduced in amount by progressive "quartering," the size of the lumps should also be uniformly reduced.

## Standard Methods of Analyses

Standardized methods for analyzing coal, coke and other solid fuels have been prepared and published by different standardization organizations. The most important of these, so far as Canada is concerned, are:—

American Society for Testing Materials . . (A.S.T.M.)
American Standards Association . . . . . . . . . (A.S.A.)
British Standards Institution . . . . . . . . . . . . (B.S.I.)

The specifications for coal and coke analyses recently advanced tentatively by the British Standards Institution follow generally the respective A.S.T.M. standard methods with slight variations in the procedure details. For coal and coke it is the practice of the American Standards Association to select and adopt A.S.T.M. methods, under their "K—Chemical Industry" designation, rather than to develop separate A.S.A. methods. Methods adopted and published either as A.S.T.M. "Standards" or "Tentative Standards" by the American Society for Testing Materials are as a matter of general interest tabulated below:—

*Methods of sampling and analyses (see footnote)*

| | |
|---|---|
| †D 21–16 | Sampling Coal. |
| D 346–35 | Sampling Coke for Analysis. |
| *D 271–33 | Laboratory Sampling and Analysis of Coal and Coke. |
| D 410–35T | Test for Screen Analysis of Coal. |
| D 311–30 | Test for Sieve Analysis of Crushed Bituminous Coal. |
| D 197–30 | Test for Fineness of Powdered Coal. |
| D 293–29 | Test for Sieve Analysis of Coke. |
| D 431–36T | Designating the Size of Coal from its Screen Analysis. |
| D 310–34 | Test for Size of Anthracite. |
| *D 291–29 | Test for Cubic Foot Weight of Crushed Bituminous Coal. |
| *D 292–29 | Test for Cubic Foot Weight of Coke. |
| *D 167–24 | Test for Volume of Cell Space of Lump Coke. |
| D 408–35T | Grindability of Coal by the Ball-Mill Method. |
| D 409–35T | Grindability of Coal by the Hardgrove Machine Method. |
| *D 141–23 | Shatter Test for Coke. |
| *D 294–29 | Tumbler Test for Coke. |
| . . . . . . . . . | Test for Agglutinating Value of Coal (Proposed Draft). |
| . . . . . . . . . | Drop Shatter Test for Coal (Proposed Draft). |
| . . . . . . . . . | Tumbler Test for Coal (Proposed Draft). |

*Specifications for:*

| | |
|---|---|
| D 166–24 | Gas and Coking Coals. |
| D 17–16 | Foundry Coke. |
| E 11–26 | Sieves for Testing Purposes. |
| E 17–36 | Round-Hole Screens for Testing Purposes. |
| †D 388–36T | Classification of Coals by Rank. |
| †D 389–34T | Classification of Coals by Grade. |

*Definitions of:*

| | |
|---|---|
| D 121–30 | Terms Relating to Coal and Coke. |
| D 407–35T | Terms Gross Calorific Value and Net Calorific Value of Fuels. |

Note—Printed copies of each of these documents are available at 25c. each in pamphlet form from American Society for Testing Materials, 260 South Broad Street, Philadelphia, Penna., U.S.A. The whole set is published as a separate volume under the title "A.S.T.M. Standards on Coal and Coke—Prepared by Committee D-5" and priced at $1.00.

The D prefix means that the corresponding standard methods of test, specifications, and definitions, were developed by Committee D-5 on Coal and Coke of the American Society for Testing Materials, the middle number, e.g. 21, 346, etc., is the serial number of the test and the suffixes are the years in which they became standard or were last revised. T, following the year, signifies that the method of test is as yet a tentative standard and † and * mark those methods that have been approved as "American Standard" and "American Tentative Standard" respectively by the American Standards Association.

At the Fuel Research Laboratories of the Division of Fuels at Ottawa the A.S.T.M. methods listed above have been largely adopted and extensively used in the chemical and physical testing of coal and other solid fuels. These methods are subject to revision at any time in accordance with the rules of the Society, which revisions and also the development of new methods are made by standing sub-committees of Committee D-5, which sub-committees are at present fifteen in number and in numerical order are: Advisory, Methods of Testing, Nomenclature and Definitions, Agglutinating Value, Pulverizing Characteristics of Coal, Foundry Coke Specifications, Coke Sampling, Editorial, Coal Friability, Sampling Coal at Coal Cleaning Plants, Mechanical Sampling, and Reduction of Samples, Dustiness of Coal and Coke, and Plasticity and Swelling. The second named author of this paper, in addition to being a member of Committee D-5 and of four of the sub-committees, is chairman of the Sub-Committee on Coal Friability and accordingly has a direct interest on behalf of the newly created Bureau of Mines in the A.S.T.M. standardization of methods for testing solid fuels and in the development of new methods of test.

## SIGNIFICANCE OF TESTS

It is to be noted that only one of the above listed methods concerns chemical analyses, viz., D 271-33, the others being physical tests. This one standard method is, however, very important since it comprises the proximate and ultimate analyses, calorific value, fusibility of ash, and the preliminary preparation of the laboratory sample. A treatise of considerable length could be written on the significance of tests for coals, but in view of articles already available,[5,6] in addition to a contemplated publication on this subject now being prepared by A.S.T.M. Committee D-5 only some aspects of the more pertinent tests will be discussed here.

### *Preparation of Sample for Analysis*

This concerns the sample after it is received in the laboratory, and involves its reduction both in size of particle and in amount, by means of either a crusher or grinder, large and small riffles, and a pulverizer of the "bucking board," planetary disc crusher, or porcelain ball-mill type. The sampling part of this preparation is of course separate from the collection of the sample and its reduction prior to sending it to the laboratory. If conducted according to standardized procedure, any errors in the final analysis due to sampling are as a rule attributable to the sampling before it reaches the laboratory. For samples appearing wet special care is taken either to air dry the sample before crushing and record the air drying loss, or to take a special (aliquot part) sample for the determination of the moisture content on the as received basis.

On the pulverized laboratory sample, prepared with or without preliminary drying, determinations for moisture, ash, and volatile matter are made separately on different portions of approximately one gram each. Of these, the volatile matter determination is perhaps the most important. In this determination, in which the coal is heated in a covered platinum crucible at 950 deg. C. for seven minutes, the gases given off consist of the moisture and volatile matter contents of the coal, leaving behind the combined ash and fixed carbon. Having previously determined the moisture and ash contents, the four components constituting the proximate analysis are recorded and reported. The per cent fixed carbon which is not determined directly is the difference between one hundred and the sum of the moisture ash and volatile matter percentage contents.

### *Volatile Matter and Fixed Carbon*

These serve, either before or after they are calculated to the pure coal basis, for classifying coals according to rank primarily for scientific purposes—for example into low, medium and high volatile bituminous coals, and into the high rank anthracite coals. The residue left in the platinum crucible after the volatile matter determination may be graded to indicate the general characteristics of a coal in respect to caking or coking. The gradings[30] reported include non-coking, agglomerating, and poor, fair or good coking.

### *Moisture, Ash and Calorific Value*

These indicate the grade of a coal so far as its chemical characteristics are concerned. The calorific value alone may be considered as representing the grade, since it is determined on the raw (air dried) coal containing moisture and ash and it is, therefore, influenced by these constituents. It is the gross calorific value as per D 407-35T that is shown in a report of analysis of a coal. The net calorific value is calculated from the gross value by making a deduction for the water formed by combustion, for which it is necessary to know the hydrogen content as determined in the ultimate analyses. The calorific value on the basis of the freshly mined coal, free of ash and mineral matter, is used for classifying the lower rank coals into different classes and groups.

*Sulphur Content*

This is an important grade specification and for accurate calorific value determinations, corrections are necessary to allow for the difference between complete oxidation when burned in the calorimeter bomb and partial oxidation when the coal is burned in an ordinary furnace. Usually only the total sulphur is shown in an analysis report, but in investigational work three different forms are determined and noted, viz., sulphate, pyritic and organic sulphur. The total, and in particular the pyritic sulphur content indicates relative ash fusion temperature—high pyritic sulphur usually means correspondingly low fusion points.

*Fusion Point of Ash (F.P.A.)*

This determination gives a general indication of the tendency of a fuel to form clinkers when burned. It affords a means of dividing coals into low, medium, and high ash fusion grades—the respective ranges recognized for these three grades being: below 2,200, 2,200 to 2,600, and above 2,600 deg. F. The ash content has an important bearing on the interpretation of the ash fusion temperature and its relation to clinkering properties, and ash fusion temperature specifications may be lowered in accordance with lowering of the ash content below that considered normal or average. Other factors allowing lowered F.P.A. specifications are physical and chemical characteristics that influence reactivity and rate of burning such as structure of a coke fuel and rank of a coal. Quality of the volatile (combustible) matter in high rank coals, e.g., in non-coking semi-anthracites, and the oxygen content of the non-coking lower rank coals, influence rate of burning; and generally, for free burning fuels the fuel bed temperature is appreciably lower than normal, thus allowing a relatively low fusion point of the ash. In an ash fusion determination three points are determinable, viz., the initial deformation temperature of coal ash cone, its softening point, and the fluid point. It is the middle temperature, viz., the softening point, that is reported as the "F.P.A." For low and certain medium ash fusion coals and cokes the softening and melting ranges are significant. These ranges are respectively the difference between the initial and the softening points and the difference between the softening and fluid points. A fuel may have a relatively low F.P.A. and still not give clinkering trouble on account of its high fluid point and consequent wide melting range.

*The Relation of Chemical Composition of Coal Ash to Its Fusion Temperature*

Within recent years this has been the subject of much research but as yet no very definite relation has been found to hold universally true. High silica and alumina contents indicate high fusion temperatures and the addition of either or both of these oxides to low F.P.A. coals, viz., those below 2,000 deg. F., has been suggested for improving their general burning qualities in respect to general clinkering properties and especially the tendency of the ash to melt and run on account of a narrow melting range. For this purpose, indications are that alumina would be about five times as effective as silica. Lime and combinations of sodium and potassium compounds, on the other hand, have the effect of lowering the ash fusion temperature. An analyst can make fifteen or more ash fusion determinations in the time required for a complete analysis of a coal ash, hence the rapid and more practical F.P.A. determination is usually requested and the chemical analysis, if made, is then useful as supplementary information.

*Screen (and Sieve) Analyses*

These tests are important for checking the sizing of coals, cokes, etc., as prepared at the mine, as delivered on the market, and as used for different purposes. In heating installations and power plants requiring pulverized fuel, a sieve analysis of the boiler feed serves to ascertain if the fuel is sufficiently fine for good combustion, and as a check on the performance of the pulverizer unit. For good combustion the fineness may be as low as forty per cent through 200-mesh sieve for certain low rank coals, but for ordinary medium to high volatile bituminous coals the percentage passing this sieve should range from seventy to eighty.

For screen analysis and size designation as per A.S.T.M. Nos. D 410-35T and D 431-36T round hole screens from eight-inch diameter down to and including ⅜-in. sized openings are specified below which the ordinary small wire cloth sieves with square openings are used. These are laboratory or plant tests for comparing coals in respect to average size and although they may be used for checking preparation at the mine they are separate from the colliery preparation where large mechanically operated screens of various types are employed. By these methods, applicable mainly to bituminous coals, the range of size is indicated by giving the lower and upper limiting screens between which 80 per cent of the sample is retained. Examples of size designations are 2-4-in. and ½-3-in. in which the order is from the lower to the upper limiting screen; "in." being the abbreviation for inches. The standard and condensed size designations proposed are applicable for testing run-of-mine, slack, and other commercial sizes of coal.

*Standard Anthracite Sizes*

For anthracite a different set of round hole screens have been adopted, as per D 310-34, in which the screens and sizing conform to the specifications of the American Anthracite Institute which are:—

| Passing | Retained on | Size Designation |
|---|---|---|
| 4⅜ inch screen | 3¼ inch screen | Broken |
| 3¼ inch screen | 2 7/16 inch screen | Egg |
| 2 7/16 inch screen | 1⅝ inch screen | Stove |
| 1⅝ inch screen | 13/16 inch screen | Chestnut |
| 13/16 inch screen | 9/16 inch screen | Pea |
| 9/16 inch screen | 5/16 inch screen | No. 1 Buckwheat |
| 5/16 inch screen | 3/16 inch screen | No. 2 Buckwheat (Rice) |
| 3/16 inch screen | 3/32 inch screen | No. 3 Buckwheat (Barley) |

While these sizes apply primarily to American anthracite, they may be of service for Welsh, Scotch and other European anthracites on the Canadian market and especially the buckwheat sizes marketed as blower fuels. When, however, a screen analysis is made on other than American anthracite it should be clearly stated and emphasized that the percentages of the stove, nut, pea, buckwheat, etc., sizes reported are equivalent to, or in terms of the respective sizes specified by the American Anthracite Institute. To the authors' knowledge there are no similar size specifications governing the British, European and Asiatic anthracite imported into Canada.

*Bulk Density*

Tests to determine weight per cubic foot of crushed bituminous coal and of coke comprise the weighing of repeated lots into a box of known volume and calculating the weight (in pounds) per cubic foot to obtain an average value for reporting. For crushed coal, less than 1½ in. in size, a cubical iron box holding exactly one cubic foot is specified and for coke a two cubic foot cubical box made of wood is recommended. In making the test the fuel is allowed to flow gently into the box which is not to be shaken or tapped during the falling and levelling off procedure. Knowing the weight per cubic foot, the cubic feet per ton can be readily calculated. Bulk density values are useful for estimating the storage space required for different fuels. A large number of these values have been made at the Fuel Research Laboratories, some of which have been published.[26,27] The bulk density varies somewhat for different sizes of clean lumps of the same fuel, due to their shape and intervening air spaces—the space required for a given weight being greater for the smaller sizes than for the larger lumps. For mixed sizes this variation tends to disappear due to the filling of the voids between the larger lumps by the smaller sizes. Domestic sizes of anthracites and bituminous coals will average about fifty pounds per cubic foot equal to 40 cu. ft. per ton. The smaller sizes of by-product coke will range from 67 to 77 cu. ft. per ton with the average about midway between these values.

*Volume of the Cell Space of Lump Coke*

Test D 167-24 (A.S.T.M.) involves the determinations of both "apparent" and "true" specific gravity, from which percentage of cell space is calculated. In this test the water displacement principle is utilized and the apparent specific gravity determination requires a correction for the water absorbed. For this test lump coke is required whereas in the determination of true specific gravity the specifications call for pulverized coke passing a 200-mesh sieve. The apparent specific gravity of the lump coke, on the market as domestic household fuel usually ranges from 0.80 to 1.00.

*Density of Coal*

For lump coal and particularly the denser, non-porous and non-friable varieties, the apparent gravity closely approaches the true specific gravity. The test, for which clean lumps two to four inches in size are recommended, may be employed for making rough estimates of the bulk density of coal "in situ"—with allowance to be considered for the compressing effect of pressure in the mine. In making "gravity" determinations at the Fuel Research Laboratories, incident to the physical and chemical survey of coals from Canadian collieries outlined in the section below dealing with coal preparation and storage, certain improvements have been effected in the apparatus and procedure. A full description of these improvements is now in manuscript form ready for publication. The cubic feet per ton values obtained show considerable variation according to ash content, and in respect to the proportion of bright and dull coal, and the fusion constituents. The lower ash coals from the Sydney and Springhill areas in Nova Scotia, for example, have specific gravities averaging 1.30, the corresponding weight per cubic foot and cubic feet per ton "in situ" values averaging 81 and 24.7 respectively. Other Nova Scotia (normal ash) coals show specific gravities ranging from 1.3 to 1.4 with corresponding cubic feet per ton values of 24.5 to less than 23.5.

*Grindability*

Tests D 408 and 409 (A.S.T.M.) are for indicating the relative amounts of energy required to pulverize coals to a given fineness using a coal of known commercial performance as a standard. Hence these tests are useful for dividing coals into different grades in respect to pulverizability. It is to be noted that the results obtained by the two methods are interchangeable by the use of a factor, so that a laboratory may choose the method preferred. The Fuel Research Laboratories (F.R.L.) at Ottawa are equipped with apparatus for making grindability tests according to both the "ball mill" and the Hardgrove machine method and also according to the F.R.L. method. This latter method was developed in the early stages of the activities of A.S.T.M. sub-committee of pulverizing characteristics of coal, as a forerunner to the ball mill method adopted, to which the F.R.L. method is similar in many respects. Results of tests on several Canadian coals by both the Hardgrove and F.R.L. method have been published[7] and the results on many more coals are on record. A grindability index of 100 or higher by the Hardgrove machine method indicates an easily pulverized coal, while indices of 30 and lower represent coals that are comparatively hard to pulverize. The values by the ball mill method corresponding to these two indices are 80 and 21 respectively.

The sieve test, as per D 197-30, is employed for determining the fineness of powdered coal and in a heating or power plant requiring pulverized fuel the test will indicate whether or not the fuel is sufficiently fine for good combustion. It also serves for checking the performance of the pulverizer. The fineness required appears to vary considerably and in accordance with the rank of coal. The manufacturers of pulverizers guarantee as high as 85 per cent through a 100 mesh. For bituminous and sub-bituminous coals, degrees of fineness down to 80 per cent through 100 mesh—with corresponding percentages through 200 mesh of 55 per cent—have been found to assure good combustion while for low rank lignite coals which are comparatively hard to pulverize percentages as low as 65 per cent through 100 mesh are allowable.

*Shatter and Tumbler Tests for Coke and Coal*

These tests are useful for indicating relative strength and handling properties. They were originally developed for testing the strength of metallurgical coke for use in a blast furnace, but they have become generally serviceable for domestic coke and lump coals.

The shatter test as applied to coke consists of dropping 50 lb. of lumps larger than two inches in size a distance of six feet onto an iron plate base of a specially constructed apparatus. The unbroken and broken lumps resulting from the first drop are returned to the box container and again dropped. This procedure is repeated until four drops have been made after which the resultant coke is subjected to a screen analysis using square hole screens. The percentage of lumps remaining on the two inch screen is the main result sought which percentage is sometimes known as the "Shatter (2 in.) Index." The proportions remaining on the smaller screens are also recorded to indicate the extent of breakage taking place in the test and accordingly to further judge the quality of the coke tested. In the tumbler test for coke 22 lb. (10 kg.) of two to three inch lumps are tumbled for fourteen hundred revolutions at 24 r.p.m. in a three-foot diameter steel drum fitted on the inside with lifting shelves. After tumbling the broken coke is screened on the same two inch square hole screen as used in preparing the sample, and then on smaller size screens. The total percentage retained on the one-inch screen is reported as the stability factor and the total on the one-quarter-inch screen as the hardness factor.

Another tumbler test applicable to coke, coal and briquettes is the "Sheffield" coke abrasion test.[8] In this test two cubic feet of 2 to 3 in. lumps of coke are rotated at a specified r.p.m. and total number of revolutions in a steel drum, without shelves, nearly filled with the charge. The total percentage of the broken coke retained on the smaller screen used in preparing the sample, viz., 2-in.

(square hole) is recorded and reported as the "Abradability Index" and the percentage passing a $\frac{1}{16}$th in. screen the "Dust Index."

A test for "dustiness" recently proposed may be mentioned here. In this test a given charge of fuel is dropped in a specified closed vertical chamber and the amount of dust formed is determined by allowing it to settle on a horizontal shutter inserted immediately after the fuel dropped has released its dust to the chamber atmosphere. The amount of dust so formed is, of course, collected and weighed, and the results are serviceable for indicating the relative dust producing qualities of various fuels and in particular the domestic sizes of coke and coal used as household fuels. This test which is now being developed by Committee D-5 as an A.S.T.M. tentative standard is useful for checking the efficiency of dedusting processes now in extensive use for domestic fuels.

In the smaller abrasion (tumbler) test the breakage taking place is considered to be largely due to the abrasive action of the lumps rubbing against each other and to a lesser extent to the shattering effect of the lumps dropping short distances against each other and against the walls of the tumbler. The breakage in the larger (coke) tumbler test is both by abrasion and shattering, whereas in the shatter test apparatus the breakage is considered to be effected largely by shattering, with a small amount only of the breakage being caused by abrasion or attrition. It is for this reason that the shatter test has been selected as applicable for testing the relative friability of coals, since it is considered that the breakage taking place during commercial handling is by shattering to a much larger extent than by abrasion. All of the above shatter and tumbler test machines and apparatus, including the apparatus for dustiness, are installed at the laboratories in Ottawa and are extensively used for testing cokes, coals, and other solid fuels.

### Coal Friability Tests

A large number of coal friability tests[9] were made at the Fuel Research Laboratories during 1932, 1933 and 1934. These were supplementary to similar tests previously made at the University of Illinois,[10] the Seattle Experiment Station of the U.S. Bureau of Mines[11] and elsewhere, and were for the purpose of comparing different laboratory friability methods in connection with the programme of the "Coal Friability" sub-committee of the American Society for Testing Materials. The tests also served for selecting a method for testing the comparative handling properties of coals incident to "an investigation of the physical and chemical characteristics of different sizes of coal from Canadian collieries' outlined below.

By friability as applied to coal is meant its liability to break and crumble into smaller pieces. Hence a friability test, which is physical in nature, serves to compare relative handling properties. The more practical method of ascertaining the handling properties of a coal in respect to friability is to examine by screening, shipments at different stages during its mining, preparation and transportation from the mine to its ultimate consumer. Comparing coals by this method, however, is too costly and what is required is a laboratory method or methods to serve as a definite measure of the comparative friability of coals. In the development of laboratory friability methods, the principle followed has been that of performing a uniform amount of work on the sample and then measuring the reduction in the average size of the lumps. Seven different methods, five tumbler and two shatter, were tried out in the experimental work in which an endeavour was made to ascertain to what extent the apparatus and methods for coke, outlined above, would be suitable for coal.

Working on seven different standard coals varying from hard non-friable anthracite to soft quite friable bituminous coals, it was found that certain variations of all seven methods could be considered satisfactory in that they placed the seven coals in the same order as to friability. Concluding that there was a need for two methods, one tumbler and one shatter as with coke, it was necessary to select these from the seven. The two methods selected are listed above as Proposed Drafts. They have recently been adopted as A.S.T.M. Tentative Standards but the designation of each has not as yet been published.

*The Tumbler Test Method for Coal*

This method employs a porcelain (pebble mill) jar, the same as is used in many laboratories for preparing coal samples, that is for pulverizing them, for analyses. For the friability test the jar is fitted with an iron frame with lifting shelves constructed according to definite specifications. The standardized procedure requires the preparation of an adequate supply of 1.05 to 1.5-in. lumps using square hole screens. A single test consists of rotating 1,000 grammes of these sized lumps for one hour at 40 r.p.m. and two or more series of quadruplicate tests are recommended. After tumbling, the contents of the jar either singly or in sets of four are screened on a specified set of ordinary screens and sieves ranging from one inch down to 50 mesh. From the screen analysis of the broken material the average size of lumps before and after tumbling is calculated and the result of the test expressed as friability per cent. This is simply the average size of the broken coal expressed as a percentage of the average size, viz., 1.275, of the lumps taken as sample. In this method both shattering and abrasion takes place and it has been suggested that the fines and dust through the 50 mesh sieve, which is considered to represent the breakage due to abrasion or attrition, be reported as the "dust index." This method, which was originally developed[12] and employed for comparing the dust producing properties of coals and cokes as delivered as household fuels, may be termed a small laboratory scale friability method. While serviceable for measuring the relative friability of coals at the mine and during subsequent handling it may also serve to indicate the extent to which lump coals will suffer degradation in certain mechanical feed devices. By this method the friability percentages range from about 20 for a low friable coal such as Pennsylvania anthracite to 60 and higher for very friable coals.

*Drop Shatter Test for Determining Size Stability of Coal*

In this test the same shatter test machine as adopted for coke (D 141-23) is used but the number of drops specified for coal are two instead of four as for coke. The breakage taking place in this test is mostly by shattering and it is considered that the extent of breakage is more in accordance with that in the ordinary handling of lump coal than in the tumbler test. The reporting of the results in terms of size stability is preferred to the term friability in that the producers of coal would more than likely favour consideration of their lump product in degree of size stability, that is its resistance to breakage, rather than in respect to degree of friability or size degradation. The size stability per cent is the difference between one hundred and the friability per cent, that is, the one is the complement of the other.

Round hole screens are used in the drop shatter test method, these being recommended in accordance with the adoption of round hole screens for the screen analysis of coal and its size designation as per D 410-35T and D 431-36T. The size of coal selected as standard for the test are 2 to 3-in. lumps and supplementary specifications are given for testing smaller and larger sizes than the standard and for mixtures of two or more of these sizes. Hence the method is considered applicable to different sizes of the same coal as well as to the same size of different coals. In addition to reporting the size stability per cent which represents the average reduction in size or rather the average overall stability of the lumps tested as ascertained by a screen analysis of the "dropped" coal, it is recommended that the "slack index," namely, the percentage through the ¾ in. screen be reported as supplementary information. This would be specially applicable when testing the relative size stability of freshly mined coal at the mine.

The size stability per cent of different coals when tested by the drop shatter test method varies from 93 to 95 for a hard (non-friable) coal to 65 and lower for very friable coals, that is when testing standard 2- to 3-inch lumps. The corresponding stability values for this and other larger and smaller sizes of a typical medium-friable bituminous coal from the Sydney area in Nova Scotia are tabulated here as a matter of general information.

| Size of Lumps (round hole screens) | Size Stability Per cent |
|---|---|
| 8 in.-12 in. | 39 |
| 6 in.- 8 in. | 46 |
| 4 in.- 6 in. | 56 |
| 3 in.- 4 in. | 66 |
| 2 in.- 3 in. (standard) | 74 |
| 1½ in.-2 in. | 79 |
| 1 in.-1½ in. | 84 |
| ¾ in.-1 in. | 88 |
| ½ in.- ¾ in. | 91 |

This illustrates how the stability varies with the size of lumps from large to small of the same coal and that the smaller lumps of a soft bituminous coal approach a stability value of hard anthracite coal, evidently due to the fact in the smaller lumps the fracture lines so apparent in the larger lumps have disappeared. On account of the effect of the cushioning effect of the "smalls" and "fines" the size stability per cent of a minus 4 in. (run-of-mine) coal mixture by this test will be as high as 95. This observance is decidedly in favour of always shipping and handling mixed sizes in which a goodly proportion of "slack" is present but for particular uses a uniformly sized product free from fines is required and the above data show that a stable lump product in the smaller sizes can be prepared from a friable coal.

## COAL CLASSIFICATION ACTIVITIES

The specifications for classification of coals by rank and by grade as per A.S.T.M. D 388-36T and D 389-34T represent committee work on coal classification inaugurated in 1927 and continuing up to the present time. This work was conducted mainly by the "Sectional Committee on Classification of Coals" functioning under the sponsorship of the American Society for Testing Materials and according to the procedure of the American Standards Association. In accordance with the rules of the latter the membership of the Sectional Committee was, and still is, composed of representatives of different interests. Out of a total membership of twenty-eight, seven represent the producers of coal, eight the consumers, two the distributors and the remaining eleven the "general interests." The detailed work involved was accomplished by three "Technical Committees" and seven sub-committees. "Coal Classification," "Nomenclature," and "Marketing Practice" are the designations of the three technical committees and of the seven sub-committees that "on correlation of scientific classification with used classification of coal" is worthy of special mention in this paper as below.

The organization just outlined has been concerned with the classification of the coals of the North American continent, including Canadian coals of course. While the membership* of the American Committees was predominantly from the United States and they were primarily concerned with their own coal classification problems, the Canadian classification interests had a prominent part in the detailed committee work. To this end the "Associate Committee on Coal Classification and Analysis" of the National Research Council of Canada, was organized in 1928 since when it has been primarily concerned with the classification of Canadian coals in co-operation with the "American" Sectional Committee. The co-ordination of the coal classification activities of the Dominion Department of Mines, the Alberta Research Council, and other Canadian research organizations has been the function[13] of the "Associate Committee" of the National Research Council. The membership of this committee includes ample representation from these organizations and from Canadian coal producers and consulting analysts as well. Although the Canadian representatives have concurred in the findings of the Sectional Committee the Canadian "Associate Committee" as a whole has yet to sanction and adopt the A.S.T.M. specifications for the classification of Canadian coals.

### *Classification by Rank*

According to the A.S.T.M. classification, rank is based on the fixed carbon and calorific value calculated to the mineral-matter-free basis—the higher rank coals being classified on the dry basis and the lower rank coals according to B.t.u. per pound on the moist (as mined) basis. Agglomerating properties, that is, weakly caking properties, and slacking indices, the tendency for certain low rank high moisture coals to slack and crumble due to weathering, are used to differentiate between certain adjacent groups. The classification into four classes and thirteen groups is summarized for ready reference in Table II.

Table II

A.S.T.M. Classification by Rank—as per Designation D 388-36T

| Classes and Groups | Limits of Fixed Carbon (f.c.) and B.t.u. (Mineral-matter-free basis) and Requisite Physical Properties |
|---|---|
| I. Anthracite class | |
| 1. Meta-anthracite group | Dry f.c. 98 per cent or more |
| 2. Anthracite group | Dry f.c. 98 to 92 per cent |
| 3. Semi-anthracite group | Dry f.c. 92 to 86 per cent, non-agglomerating |
| II. Bituminous class | |
| 1. Low volatile group | Dry f.c. 86 to 78 per cent |
| 2. Medium volatile group | Dry f.c. 78 to 69 per cent |
| 3. High volatile A group | Dry f.c. less than 69 per cent and moist B.t.u. 14,000 or more |
| 4. High volatile B group | Moist B.t.u. 14,000 to 13,000 |
| 5. High volatile C group | Moist B.t.u. 13,000 to 11,000 either agglomerating or non-weathering |
| III. Sub-bituminous class | |
| 1. Sub-bituminous A group | Moist B.t.u. 13,000 to 11,000 both weathering and non-agglomerating |
| 2. Sub-bituminous B group | Moist B.t.u. 11,000 to 9,500 |
| 3. Sub-bituminous C group | Moist B.t.u. 9,500 to 8,300 |
| IV. Lignite class | |
| 1 Lignite group | Moist B.t.u. less than 8,300 (consolidated) |
| 2. Brown coal group | Moist B.t.u. less than 8,300 (unconsolidated) |

*Canadian representatives on the "American" Coal Classification Technical Committees and Subcommittees are:—Prof. E. Stansfield of the Alberta Research Council, Dr. B. R. MacKay of the Dominion Geological Survey, and R. E. Gilmore, the latter being the sole Canadian member on the A.S.T.M. Sectional Committee and its Executive Committee. F. E. Lathe represented the National Research Council at most of the meetings of the Technical Committees.

In interpreting the limits of fixed carbon and B.t.u. specified in this classification scheme, it must be borne in mind that these values are on the mineral-matter-free basis, that is, on the basis of "pure" carbonaceous coal matter free from both ash and the mineral matter. The ash content as determined in the laboratory is always less than the mineral matter originally in the coal due to decomposition of certain constituents, and in the ordinary proximate analysis the volatile matter percentage reported on the dry coal basis is high to the extent of the mineral matter to ash, decomposition loss. As a result of considerable experimental work it was concluded that for classification purposes a ratio of 1.1, that is, eleven parts of mineral matter to ten parts of ash represents the average relation of these criteria. Immediately below are the approximation formulae recommended for correcting proximate analysis from the values as determined to the mineral-matter-free basis, in which it will be noticed the sulphur as well as the ash content is taken into account.

Dry Mineral-matter-free Fixed Carbon

$$= \frac{\text{Fixed Carbon}}{100 - (\text{Moisture} + 1.1\ \text{Ash} + 0.1\ \text{Sulphur})} \times 100$$

Dry Mineral-matter-free Volatile Matter

$$= 100 - \text{Dry Mineral-matter-free fixed carbon}$$

Moist, Mineral-matter-free B.t.u.

$$= \frac{\text{B.t.u.}}{100 - (1.1\ \text{Ash} + 0.1\ \text{Sulphur})} \times 100$$

Proximate analyses with sulphur and calorific values, on the determined, and on the calculated mineral-matter-free bases, for a typical bituminous coal from Nova Scotia and for a typical sub-bituminous (domestic) coal from Alberta are as follows:—

Typical Bituminous Coal

| | As Determined (Moist) | As Determined Dry | With m.m.* (Dry) | Dry m.m.* Free |
|---|---|---|---|---|
| Moisture..............per cent | 2.8 | | | |
| Ash (or m.m.)*........per cent | 8.6 | 8.8 | 10.0 | |
| Volatile matter.........per cent | 33.5 | 34.5 | 33.3 | 37.0 |
| Fixed carbon..........per cent | 55.1 | 56.7 | 56.7 | 63.0 |
| Sulphur...............per cent | 2.7 | 2.8 | 2.8 | |
| Calorific value B.t.u. per pound. | 13,450 | 13,850 | 13,850 | 15,390 |

Typical Sub-bituminous Coal

| | As determined (Moist) | With m.m.* (Moist) | Moist m.m.* Free |
|---|---|---|---|
| Moisture...................per cent | 18.0 | 18.0 | 18.0 |
| Ash (or m.m.)*............per cent | 5.5 | 6.0 | |
| Volatile matter.............per cent | 31.2 | 30.7 | 33.2 |
| Fixed carbon...............per cent | 45.3 | 45.3 | 48.8 |
| Sulphur...................per cent | 0.4 | 0.4 | |
| Calorific value B.t.u. per pound..... | 10,030 | 10,030 | 10,670 |

*m.m. means mineral-matter.

Referring to the A.S.T.M. Classification, it is evident that the typical Nova Scotia bituminous coal belongs to the High Volatile Bituminous A Group and the typical Alberta "domestic" coal to the Sub-bituminous B Group.

*Specific Volatile Index (S.V.I.) Classification*

This is the designation of a classification[14] devised by technical officers of the Fuel Research Laboratories, primarily for use in the by-product coking industry. The "Specific Volatile Index" is in reality the heat value expressed in B.t.u. per one per cent volatile matter content of the coal as determined in the laboratory, and is expressed as follows:—

$$\frac{\text{Determined B.t.u. per lb.} - (14{,}500 \times \text{wt. of Fixed Carbon})}{\text{Per Cent Volatile Matter}}$$

The calorific value and other chemical criteria used in this formula are on the Parr[15] "unit coal" basis in which the analyses are corrected to the basis of coal substance free of ash and mineral matter. By this scheme coals, peat and wood, are divided into eleven classes or sections, as outlined in Table III. The nomenclature shown in brackets is that of Seyler[16] whose classification was advanced particularly for English coals.

Table III

S.V.I. Classification—"Unit Coal" Basis

| Section | Name of Class | S.V.I. Limits |
|---|---|---|
| A | Woods.................................... | under 50 |
| B | Peat...................................... | 50 to 82 |
| C | Brown lignites (lignitious)................ | 82 to 99 |
| D | Black lignites (ortho-lignitious)........... | 99 to 125 |
| E | Sub-bituminous (meta-lignitious)........... | 125 to 160 |
| F | Bituminous (para-bituminous)............... | 100 to 175 |
| G | Bituminous (ortho-bituminous).............. | 175 to 190 |
| H | Bituminous (meta-bituminous)............... | 190 to 210 |
| I | Semi- or super-bituminous.................. | 210 to 230 |
| J | Semi- or sub-anthracite.................... | 230 to 255 |
| K | Anthracites................................ | 255 to 300 |

Features of the S.V.I. Classification, part only of which is shown here, are that the different sections and corresponding classes can by means of a chart be delimited by rectangular spaces, and that for typical coals in certain sections, the approximate yields and quality of the gas, tar and coke products when coked in a by-product oven can be predicted. This is specially applicable to sections E to I inclusive, in which are to be found all the coking coals—those in sections A to D inclusive and in sections J and K being non-coking.

Classification of Canadian Coals

The application to Canadian coals of both the A.S.T.M. and the S.V.I. classification systems is shown in Table IV where the arrangement under provinces and districts is that at present in use by the Canadian Bureau of Statistics. This table, which deserves detailed study, illustrates the need of a revision of the classification now used by the Bureau of Statistics, and especially for Alberta coals. By the new A.S.T.M. classification, certain of the Alberta "sub-bituminous" coals become high volatile bituminous, either Group C or B, and most of the so-called "lignite" coals of this province become sub-bituminous and are distributed into Group A, B and C of this class. Likewise, certain of the higher rank Saskatchewan coals may be classed in the sub-bituminous C group. This general promotion in classification by rank is evident also for British Columbia coals. Coals in those districts designated by the Bureau of Statistics as bituminous, however, remain as such, but are subject to sub-division into low and medium volatile groups and into high volatile A, B and C groups. It is significant to note that whereas, as previously stated, the major portion of the coal mined is bituminous and that the largest portion of the country's coal resources belong to the sub-bituminous and lignite classes, anthracites occur to a small extent in Canada. These belong to the semi-anthracite group, e.g. some of those in the Cascade (Canmore) district and certain coals found in the Colchester area in Nova Scotia and in the Kathlyn area in British Columbia.

Other classification systems[17] have, from time to time, been advanced for classifying Canadian coals, but with the exception of certain government classifications

### Table IV

Classification of Canadian Coals, Showing "S.V.I." and "A.S.T.M." Class and Group Designations

Arranged according to the Districts at present adopted by the Dominion Bureau of Statistics

| Province, District and present (1) Bureau of Statistics Classification | Production (1) in 1935—tons | S.V.I. (2) Limits and Class Designation | A.S.T.M. (3) Classification Class and Group Designation |
|---|---|---|---|
| Nova Scotia—"Bituminous" | | | |
| Cape Breton District | 4,413,570 | 147–173 (Para-) and sub-bituminous | Bituminous—High volatile A and B |
| Inverness District | 116,978 | 115–142 Sub-bituminous and black lignite | Bituminous—High volatile C |
| Cumberland (Springhill) District | 702,496 | 152–172 (Para-) and sub-bituminous | Bituminous—High volatile A |
| Pictou (Westville and Stellarton) District | 589,031 | 154–181 (Ortho-para) and sub-bituminous | Bituminous—Medium and high volatile A |
| New Brunswick—"Bituminous" | | | |
| (Minto District) | 346,024 | 153–179 (Ortho- para-) and sub-bituminous | Bituminous—High volatile A and B |
| Ontario—"Lignite" | | | |
| (Onakawana District) | | 75–101 Brown lignite and peat | Lignite—(Brown coal) |
| Manitoba—"Lignite" | | | |
| (Turtle Mountain District) | 3,106 | | Lignitic |
| Saskatchewan—"Lignite" | | | |
| (Estevan District) | 921,785 | 86–112 Black and brown lignite | Sub-bituminous C and lignitic |
| Alberta—"Bituminous" | | | |
| Cascade District (Canmore) | 152,924 | 187–259 Anthracite, semi-anthracite, Semi- (meta- and ortho-) bituminous | Anthracite—Semi and Bituminous—Low volatile |
| Crowsnest District (Bellevue to Coleman) | 1,297,394 | 158–196 (Meta- ortho- para-) and sub-bituminous | Bituminous—Medium and high volatile A |
| Mountain Park District (Cadomin and Luscar) | 651,270 | 166–209 (Meta- ortho- and para-bituminous) | Bituminous—Low, medium and high volatile A |
| Nordegg District | 147,032 | 213–239 Semi-anthracite and semi-bituminous | Bituminous—Low volatile |
| Alberta—"Sub-bituminous" | | | |
| Coalspur District | 413,489 | 105–129 Sub-bituminous and black lignite | Bituminous—High volatile C |
| Pekisko District | 4,284 | 147–159 Sub-bituminous | Bituminous—High volatile B |
| Pincher District (Lundbreck) | 1,405 | 147–159 Sub-bituminous | Bituminous—High volatile B |
| Prairie Creek District (Hinton and Jasper) | 110,192 | 147–159 Sub-bituminous | Bituminous—High volatile B and C |
| Saunders District | 37,055 | 116–134 Sub-bituminous and black lignite | Bituminous—High volatile C |
| Alberta—"Lignite" | | | |
| Ardley District | 25,778 | 97–108 Black and brown lignite | Sub-bituminous—B |
| Big Valley District | 2,651 | 94–108 Black and brown lignite | Sub-bituminous—B |
| Brooks District | 8,043 | (107*) Black lignite | Sub-bituminous—B |
| Camrose District | 57,613 | (96*) Brown lignite | Sub-bituminous—C |
| Carbon District | 95,295 | 102–118 Black lignite | Sub-bituminous—B |
| Castor District | 34,823 | 90–100 Black and brown lignite | Sub-bituminous—C |
| Champion District | 20,841 | (113*) Black lignite | Sub-bituminous—A |
| Drumheller District | 1,261,447 | 99–114 Black lignite | Sub-bituminous—B |
| Edmonton District | 493,884 | 85–103 Black and brown lignite | Sub-bituminous—B and C |
| Gleichen District | 9,172 | (108*) Black lignite | Sub-bituminous—B |
| Halcourt District | 3,753 | 128–133 Sub-bituminous | Bituminous—High volstile C |
| Lethbridge D strict | 351,004 | 110–136 Sub-bituminous and black lignite | Bituminous—High volatile C |
| Magrath District | 1,282 | 140–146 Sub-bituminous | Bituminous—High volatile B |
| Milk River District | 4,492 | (115) and (131) Sub-bituminous and black lignite | Sub-bituminous—A and B |
| Pakowki District | 2,803 | (89*) Brown lignite | Sub-bituminous and lignite |
| Pembina District | 72,163 | 82–98 Brown lignite | Sub-bituminous—B and C |
| Redcliff District | 34,150 | (100*) Black lignite | Sub-bituminous—C |
| Sheerness District | 88,877 | 93–108 Black and brown lignite | Sub-bituminous—C |
| Taber District | 14,819 | 101–123 Black lignite | Sub-bituminous—A and B |
| Tofield District | 59,500 | 91–105 Black and brown lignite | Sub-bituminous—C |
| British Columbia—"Bituminous" | | | |
| Crowsnest Pass District | 457,149 | 160–206 (Meta-, ortho- and para-bituminous) | Bituminous—Low and medium volatile |
| Inland District (Coalmont) | 93,821 | 133–142 Sub-bituminous | Bituminous—High volatile B |
| Inland District (Nicola) | 28,691 | 138–160 Sub-bituminous | Bituminous—High volatile A, B and C |
| Inland District (Princeton) | 42,003 | 111–124 Black lignite | Sub-bituminous—B |
| Inland District (Telkwa) | | 166–178 (Ortho- and para-bituminous) | Bituminous—High volatile A |
| (Vancouver) Island District (Comox) | 704,729 (Comox and Nanaimo combined) | 154–171 (Para-) and sub-bituminous | Bituminous—High volatile A |
| (Vancouver) Island District (Nanaimo) | | 142–160 Sub-bituminous | Bituminous—High volatile A and B |
| Yukon—"Bituminous" | | | |
| (Tantalus) | 835 | 141–157 Sub-bituminous | Bituminous—High volatile A |
| North West Territories | | | |
| (Great Bear Lake) | | 74–103 Black and brown lignite and peat | Lignite—(Brown coal) |

(1) The district and colliery designations shown in brackets in the first column, are added for explanatory purposes, and the coal production figures shown in the second column are those reported by the Bureau of Statistics—the producing mines for each district being listed in the annual "Coal Statistics for Canada" report of the Bureau. (2) S.V.I.—means Specific Volatile Index; the class designations shown in parentheses are according to Seyler and the S.V.I. values in this column in brackets and marked with asterisks are for single samples only from the respective districts. (3) A.S.T.M.—means American Society for Testing Materials and the class and group arrangement shown is according to Designation D 388-34T, viz., "Tentative Specifications for Classification of Coals by Rank" The calculations necessary to convert analyses from the normal ash to the "Unit-Coal" and the mineral-matter-free basis required respectively in the S.V.I. and A.S.T.M. classifications were made by G. P. Connell and the analyses used in the preparation of this Table were selected by J. H. H. Nicolls from those on record at the Fuel Research Laboratories

regulating the importation (and exportation) of coal, no complete system has as yet been adopted. The government classifications just referred to, which are in reality merely regulations, pertain to the importation of duty-free anthracite, including semi-anthracite, as distinct from dutiable bituminous coals coming under the Customs item "Coal n.o.p.," and to the exportation and importation of lignite and lignitic coal, duty-free under a reciprocity agreement between Canada and the United States. A review of these regulations is available in published[18] form, hence they need not be further discussed here.

*Type, Rank, and Grade Classifications*

In both the A.S.T.M. and S.V.I. classifications, coals are arranged according to rank, that is, according to the progressive alternation of coal constituents from peat and lignite to anthracite. The arrangement according to rank, on the mineral-matter-free basis, may be described as a classification devised by the chemist primarily for scientific purposes. The geologist is concerned with the nature of the material from which coal was originally formed, and in collaboration with the microscopist is responsible for devising "type" classification. Designations such as common or bright banded coals, splint coals, non-banded cannel coals, and algal or boghead coals, represent different types or varieties, but this subject need not be discussed further here except to say that as a result of several years study the A.S.T.M. Sectional Committee expect soon to agree on a type classification that will serve for both academic and practical purposes. A third classification is that "by grade," which is determined principally by the amount and nature of the ash, and by the sulphur content of the coal. Improvement in the grade of a coal over that as mined, may be, and is usually made in its preparation for the market. These three classifications, viz., by type, rank and grade, to which may be added a "use" classification as outlined below, are designed for use by fuel technologists, and it is hoped will be found to be of great practical value in the industrial and commercial use of coal.

*Symbols for Grade and Rank Classification*

In the specifications for classification by grade as per A.S.T.M. Designation D 389-34T, symbols are shown for grading coal according to ash, softening temperature of ash, and sulphur, the analyses being expressed on the basis of coal as sampled. A coal designated as 132–A8–F24–S1.6 indicates a heating value of approximately 13,200 B.t.u., an ash content of 6.1 to 8.0 per cent, a F.P.A. of 2,400 to 2,590 deg. F. and a sulphur content of 1.4 to 1.6 per cent. When it is desired to express both the grade and rank classification of a coal in symbol form it is suggested that the symbols indicating rank be shown in parentheses prefacing those for grade, as illustrated in the following example

(62-146) 132-A8-F24-S 1.6

The numbers in parentheses are the fixed carbon to the nearest whole per cent and the B.t.u. to the nearest hundred, on the dry mineral-matter-free basis and indicate the rank of the coal—in this case High Volatile A Bituminous.

*Use Classification*

As a conclusion of this outline of classification activities special mention should be made of the work of the sub-committee of the A.S.T.M. Sectional Committee on the Classification of Coal known as Sub-committee VI—on the Correlation of Scientific and Use Classification. The second named author of this paper, in collaboration with other technical officers of the Fuel Research Laboratories has been intimately associated with the work of this sub-committee of which he is a member. Under the title "Factors Recommended for Consideration in the Selection of Coal" a comprehensive report[19] has recently been published. This report contains seven charts illustrating the relative importance of various physical and chemical factors as applied to the following uses, viz., stationary steam generation—hand fired, stoker fired, and pulverized fuel fired, coke and gas making, ceramic products, domestic, bunker and cargo, and miscellaneous. The data shown in this report are of particular value to both the producers and consumers of coal, especially the latter, in that they designate the factors which are to be stressed in the selection of a coal for a given use. Examples showing the factors for a single variation of three different uses, viz., for steam generation (underfeed stoker), high temperature (domestic) coke making, and ceramic (terra cotta) manufacture are illustrated in Table V. The examples shown represent only one each of fifty-four, fifteen, and twenty-one different variations respectively of the three uses just specified.

TABLE V

Physical and Chemical Factors in the Selection of Coal showing their relative importance for three uses, as examples. (* means of ordinary importance, ** more than ordinary importance, *** very essential, dash means not important and blank indicates future development.)

| Factors in coal selection | Steam generation-underfeed stoker, excessive load | Domestic coke making in high temperature by-product oven | Ceramic-terra cotta manufacture in induced draft, muffle kiln |
|---|---|---|---|
| Classification | | | |
| By type | ** | ** | * |
| By rank | ** | *** | ** |
| By grade | *** | * | *** |
| Size | ** | * | * |
| Impurities | ** | ** | ** |
| Specific chemical properties of coal as sampled | | | |
| Moisture | ** | ** | ** |
| Ash—as sampled | ** | *** | * |
| Ash—chemical composition | ** | ** | ** |
| Fusing point of ash | | | |
| Initial temperature | *** | * | * |
| Softening temperature | *** | *** | ** |
| Fluid temperature | ** | ** | — |
| Volatile matter | ** | ** | * |
| Fixed carbon | ** | ** | * |
| B.t.u. per pound | ** | ** | ** |
| Sulphur—as sampled | * | ** | *** |
| Sulphur—forms | * | * | ** |
| Phosphorus | — | — | — |
| Specific physical properties of coal as sampled | | | |
| Caking properties | | | |
| Coke button | ** | * | |
| Agglutinating index | ** | * | ** |
| Swelling index | * | *** | * |
| Specific volatile index | — | * | ** |
| Specific gravity | | | |
| Of lumps | — | — | — |
| Bulk density | — | — | — |
| Plasticity | ** | * | |
| General characteristics | | | |
| Storage properties | | | |
| Spontaneous combustion | * | *** | — |
| Weathering | ** | ** | * |
| Handling properties | | | |
| Size stability | ** | — | * |
| Friability | ** | — | * |
| Grindability Index | — | * | — |
| Potential smoke producing properties | * | — | ** |

## COAL PREPARATION AND STORAGE INVESTIGATIONS

The preparation of coal is conducted mostly at the colliery, and involves screening, sizing and beneficiation by either wet or dry cleaning processes. With the exception of washing operations at Sydney, N.S. for preparing coal for the manufacture of metallurgical coke special preparation of coal has received but scant attention in Canada until quite recently. Coal was generally shipped or disposed of as it was produced at the mine—the only cleaning resorted to being that by the use of the picking belt. Today, however, the demand is both for a clean coal and for special sizes to serve the particular purpose for which it is intended, and this has compelled colliery operators to clean and size their coal not only to meet demands for a sized product for steam generation, by-product oven and other uses but also to insure good storage properties. The total and percentages of run-of-mine, screened, and slack grades representing the shipments from Canadian mines, together with a list and type of coal washeries operated in Canada is given in a recent publication[20] by the first named author of this paper. Of a total of 12½ million tons shipped in 1934 from Canadian mines, 29 per cent was run-of-mine, 38 per cent designated as "screened" and the remaining 33 per cent was slack coal.

### *Phalen Seam Survey*

An investigation under this designation was conducted during the five-year period of 1928 to 1933—and concerned a general study of chemical and microscopical characteristics of this extensive and most important coal seam in the Sydney area in Nova Scotia. In addition to the (then) Division of Fuels and Fuel Testing, the Geological Survey and the Dominion Coal Company co-operated in this investigation, in which twenty series of columnar and sectional samples from as many different locations in the seam were collected and examined. Among the results of the investigation, certain phases of which have been published,[21,22] may be mentioned the following: The microscopic study by means of thin sections showed the relative proportions of bright and dull coal, and fusain, and indicated the nature of the coal as originally deposited in the seam. The proportions of fusain (also known as mineral charcoal) and of the sulphur content, and its forms, in the columnar samples from the different locations gave valuable information in respect to variation of type and grade of the coal in the seam as the workings progressed seaward. And the analyses of the high ash content sections near the floor and roof and also of the partings, indicated to what extent the grade of the run-of-mine coal could be improved by selective mining.

### *Physical and Chemical Survey of Coal from Canadian Collieries*

This project, begun in 1932, is a comprehensive investigation designed to include all Canadian collieries working from east to west. To date the survey has covered all the collieries in the Sydney and Springhill areas, Nova Scotia, and two collieries in the Minto area, N.B. From each colliery five to ten tons of coal representing the run-of-mine coal produced, are collected, from which after screening over a four-inch (round hole) screen a ton lot, or more, of the minus-four-inch coal is shipped in boxes to the Fuel Research Laboratories. Here by means of a screen analysis it is separated into its component sizes on which physical and chemical tests are made. The physical tests conducted, in addition to the screen analyses on standard screens, comprise bulk density, specific gravity and weight per cubic foot friability and size stability, and grindability. The chemical tests made include proximate and ultimate analyses, ash fusion and composition of ash, forms of sulphur, and the distribution of fusain. Float and sink tests according to standard small scale laboratory procedure are also made from which the amenability of the coal to commercial cleaning is predicted. Certain of these tests are also made on representative samples of the plus-four-inch lumps, so that the results can be reported on the run-of-mine basis as well as on the minus-four-inch product.

The purpose of this investigation is primarily to afford fundamental information on the characteristics of different screened sizes as produced at the mine and as a result of the study of the physical and chemical properties of the coal, to predict for what uses it is most suited, either in raw state or after special preparation by sizing, washing, etc.

### *Large Scale Storage Tests*

Two series of storage tests[21] on "Dominion" Nova Scotia coal, conducted by officers of the Fuel Research Laboratories may be reviewed here. These were on "screened" run-of-mine and slack coal stock piles at Windmill Point, Montreal, during the 1928 to 1929 autumn and winter seasons, and on specially washed and sized coal at the LaSalle coke plant of the Montreal Coke and Manufacturing Company in 1931 and 1932. Storage for a period of seven months, of the screened run-of-mine coal piled fourteen feet high and provided with ventilation holes eighteen inches apart, showed practically no alteration in quality in respect to calorific value. The slack coal, however, piled to the same height, but not so ventilated did show an average loss in heating value ranging from 300 to 450 B.t.u. per pound, with no appreciable increase in ash content but with a noticeable increase in moisture content. The increase in moisture was accounted for by absorption from the air by the fines in the slack; and the decrease in calorific value was evidently due to oxidation which in turn is influenced by moisture in the finely divided coal.

The second series of storage tests served to demonstrate how the smaller sizes of coal from the Princess and Waterford mines in the Sydney area could be stored in piles thirty-five to forty feet high as required at the LaSalle coke plant. These results were effected by first washing the coal and then sizing within certain limits. The average screen analysis using square hole screens showed less than 5 per cent on one inch, about 57 per cent of one-half to one inch lumps, 35 per cent of the one-eighth to one-half inch sizes and less than 3 per cent through the one-eighth inch screen. By means of thermocouples placed at different horizontal locations and at different levels in piles varying in size from 4,000 to 35,000 tons, the absence of any appreciable heating was indicated over a period of nearly a year from the time the coal was put into storage. This was a remarkably successful result in view of the failure of unsized freshly mined coal previously tested to be stored, without heating, under the conditions prevailing. Washing effected reductions in ash and sulphur contents to less than 3 and 1.5 per cent respectively, so that the special preparation served for complying with the specifications required not only for ash and sulphur contents but also with the rather stringent storage requirements.

## COAL COMBUSTION INVESTIGATIONS

Since 1925 coal combustion investigations have comprised mainly tests on coals and coke in lump form as domestic (household) fuels and on coals as pulverized fuel for steam raising purposes. Prior to that date tests[23,24] had been made on a large number of Canadian coals in experimental gas producer and boiler installations. These were preceded by a comprehensive investigation[25] of the coals of Canada, with reference to their economic value, conducted at McGill University under the auspices of the Dominion Government. Only those combustion investigations made since 1925 and particularly since 1929 will, however, be reviewed here.

### Tests in Domestic Furnace

Two series of burning tests have been conducted in an experimental domestic hot water boiler, which may be described as the old series made in 1925 and the new series inaugurated in 1935. The new series is still in progress. The boiler used, or rather the furnace as known by the public, is an ordinary round hot water boiler of a size suitable for heating a house of eight or nine rooms. Accessory equipment used in making the tests included a radiation tank and cooling water system, scales for weighing fuel and refuse, thermometers, pyrometers, draft gauges, gas sampling and analysis apparatus and water meter calibration apparatus. In both series of tests the objective was to determine the relative value of different fuels, one with another and with a standard coal.

Pennsylvania anthracite was adopted as the standard fuel. In the old 1925 series the anthracite used averaged 14.5 per cent ash with a calorific value of 12,090 B.t.u. per pound as fired whereas in the new 1935 series the average ash content is 9.6 per cent with a corresponding calorific value of 13,190. This improvement in quality, as demonstrated in an anthracite and coke analysis survey[26] made in the 1932-33 winter season, was a factor prompting the new series of tests.

In both series a single test was conducted weekly on an individual fuel, but there were considerable differences in the method of operation, rate of combustion, etc. The old series comprised tests requiring day and night shifts, and each test was made at a constant rate of firing during the week. The feature of the tests in the new series is a changeable rate of combustion in which the coal is fired at low, medium and high rates combustion similar to actual household firing on a typical mid-winter day. During the night hours the furnace operation is automatic with test data obtainable by means of recording instruments. The new method of testing is conducted in two parts, namely, four (twenty-four hour) days to serve as a general burning observation test, followed immediately by a twenty-four hour thermal efficiency test. Even on the same standard coal, the relative results obtained by the two methods of testing would be different, but it is considered that the results of the new series of tests are more acceptable than those of the old series in that they can be interpreted more readily in terms of actual household burning conditions.

The final result sought, in a single test, is the average amount of fuel fired per therm (that is, 100,000 B.t.u.) delivered to the cooling water. From this result the tonnage of each fuel, equivalent to ten tons of American anthracite is calculated. In Table VI are listed the fuels tested in the two series of tests together with their gross calorific values as determined by laboratory analysis, and their relative actual heating values in comparison with the anthracite standard. It will be noted that in addition to anthracites, cokes and peat, the first series contained several non-coking Alberta sub-bituminous domestic coals and that the second series included several coking bituminous coals mostly from the Maritime provinces. For these coals the kind of coal and the area from which they originated are given rather than their trade and colliery names. Detailed results of the old 1925 series of tests have been published[27] but the results of the new series have been supplied from time to time to the interested parties only, subject to eventual publication to the general public when the series is completed.

The overall thermal efficiencies, as expected, varied indirectly with the volatile matter content of the different fuels and hence directly with their fixed carbon contents. The thermal efficiency in the new series averaged 66 per cent for five individual tests on the standard Pennsylvania anthracite with a volatile matter content of 5 per cent. For three different samples of by-product oven coke with less than 2 per cent volatile matter, the thermal efficiencies ranged from 72 to 76 per cent, while the average efficiency

Table VI

Burning Tests on Various Fuels in Experimental Domestic Hot Water Boiler at the Fuel Research Laboratories.

Old 1925—Series

| Designation of fuel rank and area (of Canadian origin) | Ash, volatile matter and B.t.u. as fired | | | Equivalent tonnage to 10 tons of Pa. anthracite | Equivalents recalculated to 9.6 per cent ash anthracite standard |
|---|---|---|---|---|---|
| | Ash per cent | Vol. m. per cent | B.t.u. per lb. | | |
| Pennsylvania anthracite | 14.5 | 6.2 | 12,090 | 10.0 | 10.0 |
| Welsh anthracite—cobbles | 5.0 | 7.7 | 14,080 | 8.4 | ( 9.2) |
| Scotch anthracite | 7.0 | 10.0 | 13,770 | 8.5 | ( 9.3) |
| By-product coke—stove size | 8.0 | 1.7 | 12,990 | 9.1 | ( 9.9) |
| By-product coke—medium size | 7.0 | 1.6 | 13,015 | 9.5 | (10.3) |
| By-product coke—small size | 7.3 | 1.6 | 13,010 | 9.5 | (10.4) |
| Retort (gas) coke | 12.3 | 1.9 | 12,150 | 9.8 | (10.7) |
| Pa.—Low vol. bituminous | 8.5 | 20.0 | 14,000 | 9.6 | (10.5) |
| Pa.—Low vol. bituminous | 10.7 | 15.8 | 13,890 | 9.7 | (10.5) |
| Briquettes—Welsh anthracite | 10.2 | 12.4 | 13,380 | 10.7 | (11.7) |
| Alta.—Low vol. bituminous | 13.2 | 15.8 | 13,320 | 9.9 | (10.8) |
| Alberta sub-bituminous (domestic) | | | | | |
| No. 12—Saunders area | 7.8 | 32.4 | 11,180 | 13.0 | (14.1) |
| No. 13—Coalspur area | 9.8 | 34.3 | 10,800 | 13.6 | (14.9) |
| No. 14—Lethbridge area | 10.5 | 32.7 | 10,830 | 14.0 | (15.2) |
| No. 15—Drumheller area | 7.7 | 30.2 | 9,400 | 15.0 | (16.4) |
| No. 16—Taber area | 12.5 | 31.9 | 9,610 | 15.3 | (16.7) |
| No. 17—Drumheller area | 8.0 | 31.2 | 9,540 | 14.9 | (16.3) |
| No. 18—Pembina area | 11.8 | 28.5 | 9,040 | 15.4 | (16.8) |
| No. 19—Edmonton area | 8.7 | 31.8 | 8,770 | 16.7 | (18.2) |
| Ont. peat—air dried blocks | 4.4 | 47.0 | 7,350 | 22.0 | (23.9) |

New 1935—Series

| Designation of fuel rank and area (of Canadian origin) | Ash, volatile matter and B.t.u. as fired | | | Equivalent tonnage to 10 tons of Pa. anthracite |
|---|---|---|---|---|
| | Ash per cent | Vol. m. per cent | B.t.u. per lb. | |
| Pennsylvania anthracite | 9.6 | 5.1 | 13,190 | 10.0 |
| By-product coke—stove size | 7.7 | 2.1 | 12,830 | 9.3 |
| By-product coke—stove size | 9.9 | 1.1 | 12,500 | 9.1 |
| By-product coke—nut size | 10.0 | 1.1 | 12,050 | 9.6 |
| Low-temperature coke | 8.6 | 9.6 | 12,840 | 9.5 |
| Petroleum coke | 0.5 | 9.0 | 15,210 | 8.0 |
| Briquettes—Pa. (semi-anth.) | 9.8 | 12.0 | 13,650 | 9.5 |
| Briquettes—Alta. (low vol. bit) | 9.8 | 18.6 | 14,050 | 10.7 |
| Central Pa.—bituminous coal | 8.2 | 32.0 | 13,900 | 11.7 |
| Ohio—bituminous (nut) | 8.0 | 40.7 | 13,280 | 12.5 |
| Nova Scotia—bituminous coals | | | | |
| Stellarton area | 17.9 | 27.6 | 12,320 | 11.8 |
| Springhill area | 9.7 | 31.0 | 13,440 | 12.0 |
| Westville area | 17.5 | 25.3 | 12,370 | 12.1 |
| Sydney area | 4.8 | 39.0 | 14,100 | 12.3 |
| River Hebert area | 15.1 | 36.3 | 11,880 | 13.2 |
| (Cape Breton) area | 11.4 | 32.6 | 12,530 | 13.2 |
| Sydney area | 11.0 | 31.4 | 13,540 | 13.4 |
| (Cape Breton) area | 13.9 | 34.7 | 12,080 | 13.4 |
| Inverness area | 11.4 | 37.7 | 11,300 | 14.5 |
| New Brunswick—bituminous | 21.5 | 30.1 | 11,590 | 12.9 |
| B.C.—Inland north (Telkwa) | 11.8 | 28.2 | 12,800 | 12.2 |
| B.C.—Vancouver Island | 11.6 | 39.3 | 12,500 | 12.4 |
| Alta.—sub-bituminous | 8.3 | 34.1 | 11,340 | 14.1 |
| Peat—briquettes | 5.5 | 57.1 | 8,145 | 19.6 |

of two samples of "semi-bituminous" coals with 16 and 19 per cent volatile matter was 58 per cent. The corresponding overall thermal efficiencies for the high volatile bituminous and sub-bituminous coals ranged from 50 to 60 per cent with an average of 55 per cent, which figure also represents the efficiency obtained with peat, both air-dried and machine made partially dried briquettes.

For the lower rank bituminous and sub-bituminous coals, tested in the domestic furnace, the overall thermal efficiencies varied as much as 5 per cent from the average, for approximately the same rank classification. These variations are accounted for by varying ash contents and varying physical properties such as average size of lump, and friability or tendency to crumble during handling and burning. By means of a curve obtained by plotting thermal efficiencies against fixed carbon, preferably on the dry mineral-matter-free basis, for a series of fuels varying in rank from anthracite to peat, it is possible and often practical to predict the approximate efficiency with which a given coal or coke of which the proximate analysis and calorific value is known, can be burned. Knowing the gross calorific value, and assuming a thermal efficiency, the amount of fuel required to deliver a therm to the cooling water and the consequent tonnage equivalent to the standard (anthracite) fuel can thus be calculated. However, for the bituminous and lower rank coals, an actual burning test is necessary for determining overall thermal efficiencies which vary plus or minus 5 per cent from the known average, since the variations in physical properties mentioned above, it has been found, affect the burning efficiency to that extent.

### Blower and Underfeed Stoker Tests

The hand fired tests in the domestic hot water boiler, outlined above, have been supplemented by tests in the same experimental furnace equipped first with automatic blower and then with a domestic type automatic underfeed stoker. The coals used in the blower fuel tests comprised the buckwheat sizes of anthracite marketed in Ottawa as "blower" coals—including Welsh, Scotch, Indo-China, and Pennsylvania anthracites—and two different lots of by-product oven coke. These buckwheat anthracites and pea size cokes were burned alone and in admixture with specially prepared bituminous slack coal from the Sydney area, Nova Scotia. The overall thermal efficiencies obtained averaged slightly over 68 per cent for Welsh and Pennsylvania buckwheats and from 70 to 72 per cent for the Scotch anthracite and the pea coke, all of which were judged satisfactory blower fuels for household heating purposes.

The corresponding efficiency for the screened bituminous slack was 57½ per cent. It was confirmed that such specially prepared bituminous slack coal can be used alone in blower equipped domestic furnaces, but in comparison with anthracite buckwheat it has certain disadvantages including dirty handling properties, smokiness and soot requiring the furnace to be cleaned at short intervals and caking trouble requiring constant slicing with poker—in addition to a comparative low overall thermal efficiency. Mixtures of ½, ⅓, and ¼ of the bituminous slack with Welsh buckwheat showed progressively better results as the proportion of the bituminous coal to anthracite was reduced. The use of ⅓ bituminous slack gave better results than the ½ proportion but not as good as the ¼ mixture. The general conclusion drawn is that whereas by householders accustomed to burning Welsh or other anthracite buckwheats alone the admixture of bituminous coal may not be attractive, the use of mixtures of bituminous slack with buckwheat anthracite should be considered favourably as blower fuel in localities where bituminous lump coal is now solely and satisfactorily employed as a domestic fuel.

Only a few underfeed stoker fired tests have been made using a commercial grade of bituminous slack coal from the Sydney area, Nova Scotia, and selected slack coals from two mines operating on different seams in that area. Despite soot deposit trouble requiring frequent cleaning, smoke conditions were improved, and the overall thermal efficiencies were in the range stated above for mixtures of bituminous slack with buckwheat size anthracites.

### Pulverized Fuel Tests

Pulverized fuel tests were made during 1930, 1931 and 1932 on twelve British Columbia coals, ten Alberta coals, and on four different lots of Onakawana lignite from Northern Ontario. The testing equipment was a Babcock and Wilcox marine type water tube boiler mounted over a solid refractory wall furnace haivng a hollow air-cooled floor, together with an Aero-size B high speed paddle type mill pulverizer rated at 1,000 lb. per hour, which prepares and mixes the fuel with the primary air and transmits the air-heated coal to the furnace. Three complete tests were made on each of the coals tested, one test at high rate, one at medium rate and one at low rate of feed, at approximately 20, 40 and 60 per cent of the rated capacity of the pulverizer. The objective was to obtain comparative results, one with another and with a standard operating coal selected on account of its known characteristics and its extensive industrial use as a pulverized fuel.

Detailed reports on each coal were supplied to the interested parties, including the British Columbia government for whom the tests on the coals from that province were made. A summary report on the thirteen coals from B.C. was published[28] in mimeographed form but the detailed results on the Alberta coals and on the Ontario lignite have yet to be published.

The results of these tests demonstrated that Canadian coals of varying rank and grade, with consequent wide variations in moisture, volatile matter and ash contents can be considered as suitable for use in the pulverized state. Although the thermal efficiencies of the experimental boiler used ranged roughly from 61 to 66 per cent, this being low in comparison with the better modern commercial boilers, the results do show the comparative value of the coals tested. In Table VII are shown certain selected and salient items for the different coals arranged generally in order of their rank from high to low, as indicated by their increasing moisture content and decreasing calorific values.

## COAL CARBONIZATION INVESTIGATIONS

The term "carbonization," when applied to bituminous coals in general, means the heating of the coal with exclusion of air, to distil off the liquid (tar oils and ammoniacal) products, to leave a coherent coke residue appreciably higher in carbon content than in the raw coal started with. The residue from certain non-coking varieties of the bituminous class, and from non-coking sub-bituminous, lignite, and anthracite coals is not a coke properly speaking, but is to be described as a char or carbonized residue. Carbonization investigations comprise the treatment of coals at high, medium, and low temperatures. In Canada the manufacture of coke and gas in by-product coke ovens and city gas plant is effected by high temperature carbonization, where mid-temperature and low temperature carbonization has not developed beyond the experimental stage.

### Coking Tests in By-Product Coke Ovens

A comprehensive programme of coking tests has been conducted on Canadian bituminous coals for the purpose of determining to what extent native coals may be employed in place of imported coals formerly used for the manufacture of domestic coke and city gas. These tests

Table VII

Summary of Steaming Tests on Various Canadian Bituminous, Sub-bituminous and Lignite Coals in Experimental Pulverized Fuel Fired Boiler at the Fuel Research Laboratories

| Designation of coal, name, province and rank | Rate of feed | Moisture in fuel as fired per cent | Ash content of fuel as fired per cent | Average volatile matter content on the dry coal basis per cent | Calorific value of fuel as fired (B.t.u.—gross) | Pulverized fuel passing through 200 mesh per cent | Water evaporated per lb. of fuel fired lb. | Percentage of rated boiler capacity developed |
|---|---|---|---|---|---|---|---|---|
| Standard (high volatile bituminous) operat- | Low | 3.7 | 9.5 | | 13,240 | 67.9 | 9.17 | 77 |
| ing coal | Medium | 3.3 | 8.7 | (32.5) | 13,470 | 60.3 | 8.88 | 149 |
| | High | 1.8 | 8.3 | | 13,700 | 69.5 | 8.69 | 223 |
| Low volatile bituminous | | | | | | | | |
| Canmore coal, Alta | Medium | 1.4 | 10.9 | (14.5) | 13,580 | 85.3 | 9.53 | 162 |
| Brazeau coal, Alta | Medium | 1.9 | 12.7 | (15.5) | 13,370 | 79.8 | 9.52 | 163 |
| Medium volatile bituminous | | | | | | | | |
| Luscar coal, Alta | Medium | 2.0 | 16.0 | (20.0) | 12,780 | 82.1 | 8.69 | 148 |
| Greenhill coal, Alta | Medium | 1.4 | 11.8 | (22.5) | 13,330 | 87.0 | 9.45 | 162 |
| McGillivray Creek, Alta | Medium | 2.1 | 13.4 | (24.0) | 12,810 | 78.3 | 8.93 | 152 |
| Denison coal, Alta | Medium | 1.9 | 14.4 | (24.5) | 12,660 | 79.4 | 8.68 | 148 |
| Corbin washed steam coal, B.C. | Medium | 3.8 | 13.1 | (23.5) | 12,610 | 79.6 | 8.74 | 149 |
| | High | 3.9 | 12.7 | | 12,540 | 80.9 | 8.54 | 219 |
| Cadomin coal, Alta | Medium | 2.0 | 12.7 | (25.5) | 13,110 | 87.6 | 9.58 | 163 |
| Mt. Park (M) coal, Alta | Medium | 3.0 | 12.3 | (28.0) | 13,080 | 81.0 | 9.50 | 162 |
| Michel coal, B.C. | Medium | 2.0 | 5.9 | (28.0) | 14,280 | 79.2 | 9.63 | 165 |
| | High | 1.7 | 7.7 | | 13,950 | 78.6 | 9.46 | 222 |
| High volatile bituminous | | | | | | | | |
| Hillcrest coal, Alta | Medium | 1.4 | 17.2 | (28.0) | 12,330 | 77.8 | 8.71 | 150 |
| Telkwa coal, B.C. | Medium | 5.0 | 12.8 | (32.0) | 12,470 | 71.6 | 8.48 | 145 |
| | High | 3.2 | 12.8 | | 12,820 | 66.1 | 8.49 | 216 |
| Comox coal, B.C. | Medium | 3.9 | 14.3 | (31.5) | 12,290 | 63.9 | 8.22 | 140 |
| | High | 3.9 | 14.6 | | 12,250 | 65.0 | 8.05 | 206 |
| Cassidy coal, B.C. | Medium | 3.8 | 12.2 | (38.0) | 12,440 | 69.0 | 8.42 | 144 |
| | High | 3.0 | 11.6 | | 12,630 | 67.1 | 8.21 | 209 |
| Reserve coal, B.C. | Medium | 5.5 | 14.0 | (38.5) | 11,900 | 63.2 | 8.21 | 140 |
| | High | 3.9 | 13.5 | | 12,140 | 61.6 | 7.96 | 204 |
| Wellington coal, B.C. | Medium | 6.4 | 16.3 | (37.0) | 11,380 | 66.7 | 7.59 | 129 |
| | High | 5.3 | 17.2 | | 11,330 | 67.9 | 7.51 | 192 |
| Bighorn coal, Alta | Medium | 8.2 | 9.0 | (35.0) | 11,310 | 53.7 | 8.00 | 137 |
| Coalmont coal, B.C. | Medium | 8.2 | 11.6 | (36.0) | 11,250 | 48.9 | 7.38 | 128 |
| | High | 7.9 | 10.3 | | 11,450 | 53.0 | 7.60 | 194 |
| Middlesboro coal, B.C. | Medium | 8.8 | 12.0 | (38.5) | 11,860 | 49.6 | 7.30 | 126 |
| | High | 9.3 | 11.3 | | 11,230 | 54.3 | 7.48 | 191 |
| Sub-bituminous | | | | | | | | |
| Tulameen coal, B.C. | Medium | 20.3 | 9.3 | | 9,270 | 36.2 | 6.16 | 111 |
| | High | 19.7 | 9.5 | (36.5) | 9,360 | 40.4 | 6.29 | 160 |
| Pleasant Valley, B.C. | Medium | 23.5 | 13.6 | (34.5) | 8,080 | 52.6 | 5.37 | 94 |
| | High | 22.9 | 13.3 | | 8,110 | 41.9 | 5.34 | 137 |
| Lignite from N. Ontario | | | | | | | | |
| Onakawana, air dried | High | 31.5 | 7.7 | (43.0) | 7,010 | 63.1 | 4.58 | 117 |
| Onakawana, mine run | High | 46.7 | 7.4 | (42.0) | 5,280 | 62.7 | 3.16 | 80 |

have been made both at different by-product oven coke plants and at the Fuel Research Laboratories—where facilities are available for conducting tests on small, intermediate, and large scales—and may be listed as follows:—

(1) 1923—Coking tests on four coals from the Maritime Provinces, three from Nova Scotia and one from New Brunswick, in the ovens of the Hamilton By-Product Coke Ovens, Limited, Hamilton, Ontario.

(2) 1930 and 1931—Coking tests at Ottawa on eight coals from British Columbia, on six coals from Alberta, and on a specially prepared Nova Scotia coal from the Sydney area—the latter when blended with certain imported coals in comparison with the standard mix of American coals.

(3) 1930 (December)—Coking tests at Winnipeg on Michel, B.C. coal in comparison with Allison, Pennsylvania, coal. These tests were made in the ovens of the Winnipeg Electric Co., and were preceded in 1927 by special small-scale box coking tests on several coals from western Canada.

(4) 1931 (September and November)—Coking tests at Montreal on washed Princess coal, a specially prepared bituminous coal from the Sydney area, Nova Scotia, in admixture with certain American coals. These tests were made in the ovens of the Montreal Coke and Manufacturing Company.

(5) 1933 (April)—Coking tests at Vancouver on selected coals fromBritish Columbia and Alberta in the (new) ovens of the British Columbia Power and Gas Company.

(6) 1933 (May)—Coking tests at Brandon on Michel, B.C. coal at the gas plant of the Manitoba Power Commission.

(7) 1936 (October)—Coking tests at Hamilton on a mixture of Princess and Waterford coals from the Sydney area, N.S., in the ovens of the Hamilton By-Product Coke Ovens, Ltd.

(8) 1933, 1934, and 1936—Coking tests at Ottawa in two different 500-lb. capacity ovens, for studying the characteristics of coals when blended with one another and with inert coke breeze, and for testing the amenability of Canadian coals to mid-temperature carbonization.

Summaries of the results of all these coking tests have been published,[29, 31, 32] hence only the salient points of this series of investigations will be reviewed here.

For the manufacture of high quality domestic by-product coke, a coal must comply with quite rigid specifications if it is to be coked alone. Such coals, native to Canada, are somewhat limited in number, for which reason the usual practice is to use a two, or three, or even a four coal blend. In plants where gas is considered the main product and coke secondary, a bituminous coal with 33 to 35 per cent volatile matter may be used. But in plants where either domestic or metallurgical coke is the main product and gas secondary, a coal or coal blend with about 30 per cent volatile matter is required. The following table gives the composition of typical one, two, three, and four coal blends.

| Kind or rank of coal | High volatile bituminous | Medium volatile bituminous | Low volatile (semi) bituminous |
|---|---|---|---|
| Volatile matter content. per cent | 33 to 35 | 29 to 31 | 16 to 18 |
| One coal.............. per cent | | 100 | |
| Two coal blend........ per cent | 55 | | 45 |
| Three coal blend....... per cent | 56 | 28 | 16 |
| | or 35 | 50 | 15 |
| | or 40 | 40 | 20 |
| Four coal blend........ per cent | 40 of (*a*) | 25 | 20 |
| | 15 of (*b*) | | |

(*a*) and (*b*) designate two different high volatile bituminous coals.

The usual practice is to crush each of the coals before blending, and typical screen analyses of the coal mix charged to the ovens show from 40 to 80 per cent through a ⅛ in. round hole screen. This practice, adopted generally for by-product oven coking, is different from that employed in vertical gas retorts when run-of-mine or specially prepared lump coal is charged without crushing.

A prerequisite characteristic of prime importance when a bituminous coal is coked alone or blended with one or more coals is that the coal or coal blend will have the desired contracting properties in the latter stages of coke formation, suitable for use in the particular type of by-product oven in which it is used. The structure and other physical characteristics of the coke produced are also very significant, with the chemical properties of secondary importance.

The structure specifications of a high grade by-product oven coke, for use as a domestic household fuel, are different from those for a metallurgical or foundry coke mainly in respect to shape and strength. A properly-sized metallurgical coke, however, makes a good domestic coke. Significant physical properties of run-of-oven coke influencing general structure, include appearance, size and shape, cross and longitudinal fracture, cell structure, sponginess, hardness, and ring when struck. A good domestic coke as marketed, should be square or rectangular in shape, and when the large run-of-oven coke is crushed and screened into the different egg, stove, nut, and smaller sizes, the structure should be such that a maximum proportion of the higher price larger sizes are produced, with a minimum amount of low price smaller sizes and breeze.

The ash content, and in particular the fusion point of ash, are important, but in Canada the requirements, or rather the allowable specifications in this respect, for a domestic coke may vary considerably according to the part of the country in which the coke is marketed. The reason for this is that the properties of the fuel accepted as standard in a given locality regulate the specification requirements of domestic coke as a substitute fuel in that locality. For example, in the localities in the extreme eastern and western parts of the country, in the coal mining areas, bituminous lump coal is the standard domestic fuel. Such bituminous coal has varying coking or caking properties when burned and is smoky to varying degrees. A characteristic of the coals mined in the Maritime provinces is their relatively low fusion point of ash, and householders using these coals as domestic fuel have become accustomed to, and have learned how to burn them without experiencing troublesome clinkering. Hence, there, a domestic coke with ash fusion temperatures in the lower range, from 2,300 deg. F. to as low as 2,000 deg. F. will likely be found acceptable as a substitute fuel, providing the ash content of the coke is low, say not over seven to nine per cent. With the exception of certain coals in the Crow's Nest Pass area, the coals of British Columbia and especially those from Vancouver Island have medium ash fusion temperatures, from 2,300 deg. F. to 2,400 deg. F., with relatively high ash contents. These coals have free burning characteristics, and are not strongly caking. For these reasons a substitute coke fuel, in Vancouver and neighbourhood, need comply with less dense structure specifications than required elsewhere for by-product coke. The ash content also may range as high as 15 to 18 per cent, and still be quite satisfactory for household heating purposes.

The requirements for coke in Winnipeg and other large centres of Manitoba, in respect to structure, ash content, fusion point of ash, etc., are intermediate between those for coke on the Pacific coast and in Central Canada The extensive use of Alberta "domestic" grades of sub-bituminous and lignite coals in that district has accustomed householders to a free-burning fuel, for which oversize furnaces are in extensive use. For these users, a free-burning coke with medium to low ash fusion temperature would be acceptable. However, for those who require a substitute for imported anthracite, the best grade of by-product coke in respect to structure, ash fusion and general burning qualities is required.

These are also the requirements of a by-product coke in Central Canada, from Montreal to the Great Lakes. In this central portion coke has to compete with Pennsylvania, Welsh, Scotch, and European anthracites. Hence, a coke fuel must be dense to keep its bulk density in terms of cu. ft. per ton as low as possible, and be of the proper cell structure and density to permit the desired rate of burning. It must be low in ash content and high in ash fusion temperature. An ash fusion temperature of 2,700 deg. F., or higher, signifies a high grade coke fuel, but it has been ascertained by burning tests that for a coke with seven to nine per cent of ash, an ash fusion temperature as low as 2,500 deg. F. will insure comparative freedom from clinker trouble.

*General Coking Test Conclusions*

The tests in 1931 on specially prepared coal from the Sydney area showed that as high as 35 per cent of the specially washed and sized Nova Scotia coal could be used in the coal blend without reducing the ash fusion temperature of the coke seriously below 2,500 deg. F., and that the coke produced was equal in all respects to that from the blend of one hundred per cent imported coals formerly used. As a result of the test in 1936 at Hamilton it was found that selected unwashed run-of-mine "Sydney area" coal could be blended in proportion up to 35 per cent to give a satisfactory by-product, providing the medium and low volatile bituminous coals used in the blend had certain stipulated high ash fusion temperatures. The tests in 1930 at Winnipeg demonstrated that a selected coal from the Crow's Nest area in British Columbia could be satisfactorily employed in place of the imported coal formerly used. Likewise the tests at Brandon in 1933 showed that a Crow's Nest Pass (B.C.) coal could be satisfactorily substituted for the formerly used Pennsylvania coal for the manufacture of city gas and "gas" coke. The tests in Vancouver in 1933 were comprehensive and demonstrated what inland British Columbia and Alberta coals could be employed in admixture with Island coal to obtain different grades of coke in respect to structure, ash content, etc., satisfactory for the Vancouver market, and still give the desired yield and quality of city gas.

Prior to about 1923 the only public utility plants using Canadian coals for the manufacture of city gas and domestic coke were those at Halifax and Vancouver. These were primarily city gas plants with coke as a by-product. The status of the Halifax plant, which has Glover-West retorts, has not changed materially, its present coal consumption being about 12,000 tons annually; in Vancouver, the old gas retorts have been replaced by new (vertical) by-product ovens, with an annual coal consumption of over 56,000 tons. In the Woodhall-Duckham retorts at Quebec, Nova Scotia coal is used exclusively to the extent of nearly 20,000 tons. 185,000 tons is the approximate annual consumption of Canadian coal at the LaSalle plant, Montreal, representing approximately one-third of the total coal used in the Koppers (Becker) horizontal by-product ovens there. The amount of coal coked annually in the Koppers by-product ovens at Winnipeg is over 50,000 tons, where Canadian (B.C. Crow's Nest) coal has recently been used exclusively. Hence, the economic significance to date of the trend towards a greater use of Candian coal for the manufacture of domestic coke and gas, in which the coking tests referred to above have played an important part, is represented by a total increased annual consumption of nearly 300,000 tons.

Coking plants, up to the present, not using Canadian coal are the city gas (and coke) plants at Ottawa and Toronto, the coking plant of the Algoma Steel Corporation, at Sault Ste. Marie and the two large by-product coke plants at Hamilton, viz., those of the Hamilton By-Product Coke Ovens, Ltd., and the Steel Company of Canada. As indicated above, large scale tests have, however, been made at both Ottawa and Hamilton, and it is hoped that Canadian coal can be introduced in plants in these centres as well as in Toronto in the not too distant future. The 300,000 tons annual consumption of Canadian coal for domestic coke mentioned above is, of course, exclusive of slightly under 500,000 tons of Nova Scotia coal used annually in the manufacture of metallurgical coke in the Koppers ovens of the Dominion Steel and Coal Corporation at Sydney, and of nearly 150,000 tons of British Columbia coal used in bee-hive ovens in the Crow's Nest Pass area for the production of metallurgical coke.

The commercial plant scale tests at Montreal and Winnipeg confirmed the results obtained in the experimental oven of two-ton capacity at the Fuel Research Laboratories at Ottawa. Supplementary information is obtained at the Ottawa laboratories as to the comparative yields of gas, tar oil, and other products, by testing individual coals, or coal mixtures, on a small 20-gram scale by what is known as the tube test, which is in reality a high temperature carbonization assay. By means of this test, together with a laboratory swelling index test,[33] the carbonization engineers are able to predict the general coking characteristics, the yield, and general physical properties of the coke, the yields of light and heavy tar oils, and the yield and thermal value of the gas, that may be obtained when a coal or coal blend is coked in a commercial by-product oven. Ability to make such predictions, however, it should be mentioned, has resulted from a comprehensive study of the results obtained in the experimental and commercial ovens on a large number of coals, and depends on the accumulated knowledge of the engineers making the small scale laboratory tests.

### Special Blending and Mid-Temperature Carbonization Tests

The coking tests listed under (8) above were carried out for the purpose of ascertaining the coking properties of coal on a smaller scale than that allowable in the large experimental oven at Ottawa and in commercial ovens. Two ovens each having a capacity of approximately 500 lb. of coal were built and experimental tests were made in them, Two ovens having a capacity of approximately 500 lb. of coal were built and experimental tests were made in them, these ovens being known as the high temperature 16 in. wide oven and the other the mid-temperature 12 in. oven. The feature of these ovens is that sufficient coke is produced from individual 500 lb. coal charges for examination as to structure and other physical properties and for chemical properties as well, the coke obtained being similar in quality to that produced in commercial ovens.

Tests in the 16 in. high temperature oven operated at an average flue temperature of about 2,200 deg. F. are for the purpose of studying the coking characteristics of coals, before and after washing, when blended with one another and with inert material. Coals from western Canada, not previously tested in the large ovens, have been tested in this oven and the results show that a large proportion, when either washed or properly prepared, or blended with other suitable coals, are suitable for the manufacture of city gas of the required quality and of coke entirely satisfactory for the domestic market.

Tests in the 12-in. mid-temperature oven operated at an average flue temperature of 1,400 deg. F. are carried out for studying the effect of the blending of inert material such as coke breeze, anthracite fines, fusain, etc. with Canadian and other coals. The results of the tests carried out in this oven have indicated how a particular coal from New Brunswick, previously considered unsuitable for carbonization on account of its high ash and sulphur contents, can be first washed and then blended with coke breeze from a former test on the same coal, to produce a high quality coke, quite different and equal to (if not better than) the better grades of high temperature coke, in respect to physical properties. This has proved to be one of the most important results of these tests. Some of the principal features of these improved qualities of the coke are the remarkable uniformity of cell structure, the absence of minor fissuring common to high temperature coke, and the high apparent specific gravity.

### Low Temperature Carbonization

By low temperature carbonization is generally meant carbonization at temperatures varying from 500 to 600 deg. C., that is from about 900 to 1,100 deg. F. Generally speaking, the relative temperatures for low and high temperature carbonization may be kept in mind as 1,000 deg. F. for low temperature and 1,000 deg. C. for high temperature. The latter temperature, equivalent to 1,800 deg. F. is, however, the approximate flue temperature of the coke oven rather than the average maximum temperature within the oven during the progressive coking of the coal from the hot walls to the centre of the charge which ranges from 1,500 to 1,600 deg. F. For mid-temperature carbonization which may be interpreted as midway between high and low temperature, the flue temperature may vary somewhat from 1,400 deg. F., stated above, with a corresponding average maximum temperature within the oven 200 to 300 deg. F. lower.

The literature on low temperature carbonization is very extensive, and since the scope of this paper does not allow space for its review, only some salient points as applied to Canadian coals will be mentioned here. The present status of low temperature carbonization in Canada is that all attempts to introduce it on a commercial scale have so far met with failure. Its main disadvantage for bituminous coals is that very few of the processes promoted will produce a coke product as satisfactory for the domestic fuel market as the ordinary by-product oven domestic coke. The low temperature product is grayish-black in colour, and as a rule has poorer handling qualities than the high temperature coke. It is free burning and quite serviceable for open grates and cooking purposes for which it was originally promoted in England where also its smokeless properties were in its favour.

The high temperature yield of gas is such that a surplus over and above that required for heating the ovens of 7,000 cu. ft. of 500 B.t.u. gas or more, is available for sale, whereas by low temperature, there is no such surplus, despite the fact that the heating value of the low temperature gas is appreciably greater. The doubled yield of tar oil which is a feature of low temperature carbonization is not specially attractive since its value in the raw state is not greater than that of fuel oil. The yield of coke is appreciably higher by low temperature but unless the coke produced can be sized and marketed at a greater profit per ton of coal carbonized than by the high temperature process thus offsetting the deficiency in surplus saleable gas, any advantages claimed for low temperature carbonization disappear.

A considerable number of low temperature carbonization tests on Canadian coals have been made at the Fuel Research Laboratories (F.R.L.). These have been on small and large laboratory scales and the results have been published.[34,35] The results of assays are on record for a large number of coals varying in rank from lignite and peat to semi-anthracite, by a recently developed F.R.L. low temperature carbonization assay method. These results are being specially correlated with the classification by rank of the coals tested and will be the basis of a manuscript for publication in the near future.

The first named author of this paper during his visit in 1928 to Europe inspected several low temperature carbonization plants, then in the development stage, including the retorts developed by the Fuel Research Board at Greenwich, the Illingworth plant at Pontypridd, the Turner, Sutcliffe, Babcock Wilcox, the L and N plants, all in Britain, and four plants in Germany including the Lurgi retort plant. A summary was published[36] of the relative merits of these processes and the reasons for selecting the Illingworth process as the most suitable for Canadian bituminous coals. The application of low temperature carbonization to the coking and non-coking (domestic) coals of Alberta has recently been described.[37] Significant points stressed in the references 36 and 37 may be summed up as follows:—Attempts to adopt processes which have been successful in one country to conditions in another country have rarely succeeded and claims that a process is universal in application are a proof of ignorance or worse: the best processes are liable to fail to pay dividends in any but the most favourable locations. Furthermore the success of any low temperature carbonization process in Canada will depend on low capital cost of plant per ton year—materially lower than the present cost of either by-product oven or gas plants—and on the ability to utilize a low grade and inexpensive raw fuel.

The results obtained in some large scale tests made on selected Canadian coals in the experimental plant of the Illingworth Carbonization Company in South Wales are worthy of special mention here. These tests, which were made on unwashed and washed Sydney, Nova Scotia coals were planned and witnessed by officers of the Fuels Division of the Canadian Department of Mines and the detailed results have been published,[38] reprints of which are available. The yields and certain chemical characteristics of the coke and other products obtained by the Illingworth low temperature process in comparison with the corresponding results in a high temperature coke oven, using two different washed coals from the Sydney area Nova Scotia are shown in Table VIII and the relative low temperature carbonization laboratory results on typical Alberta bituminous, sub-bituminous and domestic coals are given in Table IX.

Table VIII

Results of Carbonization of two different samples of washed Sydney, N.S. Coal, by low-temperature carbonization in comparison with those at high temperature.

| | High-temperature carbonization in by-product oven | Low-temperature carbonizaiton by Illingworth process | |
|---|---|---|---|
| Analysis of coal | | | |
| Ash (dry coal basis)....per cent | 3.5 | 5.8* | (4.3) |
| Volatile matter....per cent | 38.0 | 28.0* | (31.0) |
| Products obtained, per ton of dry charge | | | |
| Coke (dry)....lb. | 1,340 | 1,590 | (1,550) |
| Ash in coke....per cent | 4.8 | 7.7 | |
| Volatile matter....per cent | 2.0 | 8.1 | |
| B.t.u. per pound.... | | 13,850 | |
| Sulphur in coke....per cent | 1.0 | 2.4 | |
| Tar oils....Imp. gal. | 11.0 | 14.0 | (15.5) |
| Gas (including light oils)....cu. ft. | 12,700 | 5,500 | (6,085) |
| B.t.u. of gas.... | 595 | 705 | |
| Light oils extractable from gas....Imp. gal. | 2.5 | 2.9 | (3.2) |

*This is the analysis of the coal charged after admixture of ten per cent breeze from a previous test, hence the coke yield of 1,590 lb. is subject to correction. Figures given in brackets in the last column to the right are the calculated analyses and yields based on one hundred per cent dry coal without the breeze. The volatile matter content of both the coal and the coke is low, as it was determined in silica crucibles at the Illingworth plant in England.

The tar oil yield by the laboratory low temperature carbonization assay from the washed Sydney, Nova Scotia coal on which commercial yields are reported in Table VIII is 26 Imperial gallons, practically equal to that for high volatile bituminous from the eastern border of the Crow's Nest area in Alberta reported in Table IX. It is further noted that the tar oil yields of the typical medium volatile, and of the sub-bituminous and domestic coals from Alberta are comparatively low, ranging from 18.5 to 11 Imperial gallons per ton; and also that the carbonized residue from the sub-bituminous and low rank domestic coal is a char rather than a coke. For these reasons as referred to below and also because of their relatively low char yield, as well as the lower heating value of the gas, low temperature carbonization for the lower rank non-

Table IX

Results of laboratory low-temperature carbonization assays at 600 deg. C. on typical Alberta bituminous sub-bituminous and "domestic" coals.

| | Bituminous coals from Crow's Nest area | | Sub-bituminous coal from Saunders Cr. area | "Domestic" coal from Drumheller area |
|---|---|---|---|---|
| | Medium volatile coal | High volatile coal | | |
| Analysis of coal | | | | |
| Moisture (as mined)....per cent | 1.5 | 4.0 | 10.0 | 21.0 |
| Ash—Dry basis....per cent | 5.4 | 7.8 | 5.8 | 6.1 |
| Volatile matter—Dry basis per cent | 27.8 | 35.2 | 37.9 | 38.1 |
| Fixed carbon—Dry basis...per cent | 66.8 | 57.0 | 56.3 | 55.8 |
| B.t.u. per lb.—Dry basis.... | 14,550 | 13,600 | 13,050 | 12,200 |
| Products per ton coal as mined | | | | |
| Nature of carbonized residue.... | Coke | Coke | Char | Char |
| Coke or Char....lb. | 1,600 | 1,400 | 1,300 | 1,100 |
| Ash content of dry coke...per cent | 6.9 | 11.1 | 7.7 | 8.3 |
| Volatile matter of dry coke per cent | 7.3 | 6.2 | 7.3 | 6.4 |
| Fixed carbon of dry coke..per cent | 66.8 | 82.7 | 85.0 | 85.3 |
| B.t.u. per lb. of dry coke.... | 14,000 | 13,500 | 13,900 | 13,850 |
| Ammonia from liquor....lb. | 5.5 | 10.0 | 13.0 | 18.0 |
| Tar Oils—including light oils from the gas....Imp. gal. | 18.5 | 26.5 | 16.0 | 11.0 |
| Gas—free of light oils....cu. ft. | 3,475 | 3,730 | 3,755 | 4,030 |
| B.t.u. per cu. ft. of gas.... | 715 | 655 | 525 | 525 |

coking coals is not an especially attractive proposition, since for these coals it is often difficult to realize the main objective of carbonization which is to convert coal into new products of greater value than the raw fuel carbonized

### FUEL BRIQUETTING INVESTIGATIONS

Briquetting is applicable to several different kinds and forms of fuel including anthracite fines, coke breeze from bituminous coals, petroleum coke breeze, char resulting from the carbonization of non-coking coals, the fines from low-volatile bituminous, sub-bituminous and domestic coals in the raw state, and in addition such materials (either raw or carbonized) as peat, sawdust, straw and grain screenings. The purpose of briquetting is obviously to convert either the raw or carbonized fuel, usually in the form of slack, fines or breeze, into a more saleable lump product. The size and shape of briquette varies from small size oval or pillow shaped briquettes corresponding to ordinary nut and stove size anthracite, to much larger cylindrical and cubical shaped briquettes that are either burned as such or broken down at the time of firing.

The briquetting process consists of intimately mixing while hot the suitably sized coal or other raw material with a binder and then feeding the hot mass to a powerful press where it is moulded into the briquettes. Careful handling of the briquette is usually required during the cooling stage between the briquetting press and the storage bin. Such binders as petroleum asphalt, and coal tar pitch are most commonly used. Other binders that have merits are pitch or powder from sulphite liquor, and flour, either alone or as a paste emulsion with oil binder. The admixture of a coking low volatile bituminous coal is often used to improve the internal caking strength of the briquette during the first stage of burning and to increase the calorific value of the briquette. Oxidized pitch from Alberta bitumen has also been found, both in tests at Ottawa and Edmonton, to be as satisfactory a briquette binder as pitch from either petroleum or coal tar.

A feature of the briquetting facilities at Ottawa is the commercial size briquetting plant with a capacity of five tons per hour capable of either continuous or intermittent operation. A Mashek roll press is used in conjunction with three mixers, two of which are steam jacketed, elevators, conveyers, and suitable binder tanks and feeding devices. For batch (intermittent) tests a steam jacketed mixer with a capacity of 50 to 75 lb. of coal is employed for preparing the charge for the briquetting press. A variable pressure plunger press, a hand operated hydraulic press, together with adequate steam boilers complete the briquetting equipment.

Briquetting tests have been conducted at the Fuel Research Laboratories intermittently since 1918. These have included briquetting tests on (*a*) carbonized lignite incident to carbonizing and briquetting investigations on lignite from southern Saskatchewan and northern Ontario, (*b*) Welsh anthracite screenings, (*c*) petroleum coke breeze, (*d*) hardwood charcoal breeze, and (*e*) fines from eight British Columbia coals.

In a recent publication[39] entitled "Fuel Briquetting" the results of these tests are given in detail and the status of fuel briquetting in Canada and in the United States reviewed. The comprehensiveness of this publication which includes a complete review of recent literature on the subject as well as a list of briquetting patents with special reference to binders may be indicated by stating the titles of the six chapters. They are as follows:—History of briquetting, Processes for briquetting various classes of fuel, Binders and processes for briquetting, Equipment used in briquetting, Investigations on briquetting, and Economics of briquetting.

As a part of the briquetting investigational programme conducted at the Fuel Research Laboratories, a survey was made of commercial briquettes on the market in both Canada and the United States. The chemical analyses of the briquettes have been reported[40] and their physical properties are given in the "Fuel Briquetting" publication. As with sized coal and coke it is mainly the physical characteristics that determine the relative merits of different briquetted fuels, although the chemical properties in respect to ash content, volatile matter, smokiness and calorific value are important. Accordingly the briquettes included in the survey and those produced in the laboratory briquetting tests, were examined in respect to the following physical properties, viz., apparent specific gravity; bulk density in terms of weight per cubic foot; waterproofness and shatter; abrasion and compression tests to indicate comparative handling properties. Depending on the quantity available, the usual practice is to make either small or large scale burning tests to determine the smokiness of the briquettes and the degree to which they soften and coalesce in the fire. The survey indicated a wide variation as to type of briquette marketed, which variation was accounted for by the variation in the fuel accepted as standard in the different localities. The relative heating values of two different lots of anthracite briquettes, one made from Pennsylvania semi-anthracite fines and the other produced in Western Canada from low volatile bituminous coal, in comparison with Pennsylvania anthracite and other domestic fuels are shown in Table VI.

A study of the results of the briquetting tests on eight coals from British Columbia ranging in rank from lignite to medium volatile bituminous revealed that the physical properties in respect to strength, etc., of the briquettes, made with a constant proportion of (145 deg. F. melting point) coal tar pitch, varied directly with the rank of the coal. The shatter index, as indicating resistance to breakage, increased from low to high rank and the dust producing properties of the briquettes, when subjected to a standard laboratory tumbling test, decreased according to rank, being the greatest for the non-coking lignite and sub-bituminous coals and the least for the coking medium volatile bituminous coals.

The beneficial results of blending a good coking coal with the non-coking coals for briquetting purposes was confirmed and it was found that the optimum quantities of the coking coal to be added ranged from 25 per cent for the non-coking sub-bituminous (and lignite) coals to as low as 5 per cent for anthracites. The addition of a coking coal to the non-coking lower rank coals, it was also confirmed, improved their general burning qualities. In fact without the admixture of a coking coal these lower rank coals are unsuitable for briquetting since briquettes made from them disintegrate badly when burned, due to their high volatile matter contents.

#### Briquetting of Carbonized Residue

The merits of the double treatment of carbonization and briquetting versus the briquetting of the raw coal fines has received considerable attention at the Fuel Research Laboratories and elsewhere in Canada. In this connection the relative calorific values of typical coals of different rank in the raw, dried and carbonized states, as tabulated below, are significant.

The data in this table indicate generally what ranks of coals may best be briquetted in the raw or dried state and what ranks may be suitable for the double treatment of carbonization and briquetting. It is to be noted that the calorific values of the char are progressively higher than those of both the raw and dry coal as the rank decreases from noncoking high volatile bituminous coal to lignite, whereas in the high rank anthracites (and low volatile bituminous coals) the reverse is the case. The increase of calorific value by drying alone in comparison with the added increase by carbonization is also illustrated.

TABLE X

| Selected typical coals (Moisture, ash and volatile matter contents in brackets) | Calorific Values—B.t.u. per lb. | | |
|---|---|---|---|
| | Raw coal as mined | Dry coal basis | Char after carbonization at 600 deg. C. |
| Alberta—Semi-anthracite (3–8–11)* | 13,900 | 14,300 | 14,200 |
| Alta.—High volatile bituminous (10–8–38) | 11,550 | 12,850 | 13,750 |
| Alberta—Sub-bituminous (15–9–38) | 10,150 | 11,950 | 13,050 |
| Alta.—(Sub-bituminous) domestic (25–10–37) | 9,300 | 11,250 | 12,780 |
| Saskatchewan lignite (35–11–43) | 7,150 | 11,000 | 12,500 |
| Northern Ontario lignite (50–11–44) | 5,250 | 10,500 | 12,220 |

*Example—3 per cent moisture, 8 per cent ash and 11 per cent volatile matter, with the ash and volatile matter on the dry coal basis.

The char resulting from carbonizing the lower rank non-coking coals is porous and therefore requires appreciably more binder when briquetted than the raw coal, both low and high rank. This porosity of the char, which tends to increase with decrease in rank, is influenced appreciably by the temperature of carbonization. For lignites in particular, the maximum calorific value in the char is obtained at 550 to 600 deg. C., but the fact that char produced at higher temperatures, say up to 850 deg. C., has appreciably better briquetting properties must be taken into account.

In the establishment of briquetting plants in Canada, and also in the United States, the same degree of success has not materialized as in Europe. This is mainly due to the difference in the available fuels and their method of utilization. In Europe the briquetting industry seems to have been established for converting the fines from all ranks of coals into a more useable form irrespective of a specific standard, whereas in North America fuel briquetting has been confined almost exclusively to the production of a domestic briquette in competition with anthracite. In Canada recent briquetting ventures have been mainly associated either with the carbonization of lignite of the grades found in Southern Saskatchewan and in Northern Ontario, or with the semi-anthracite and low volatile bituminous coals of Alberta. Anthracite briquettes, imported from either the United States or Great Britain, are marketed in Central Canada, where recently cubical shaped packaged briquettes made mostly from low volatile ("semi") bituminous coal are also on the market.

Briquetting was conducted in conjunction with carbonization operations at Bienfait, Saskatchewan, intermittently from 1918 to 1930, first by the Lignite Utilization Board[41] and then by the Western Dominion Collieries.[42] While it is understood that financial considerations were mainly responsible for the discontinuance of operations, it is believed other factors such as competition of Alberta and other domestic fuels, and also the increased use of Saskatchewan lignite in the raw state in Winnipeg, Regina and other centres in Manitoba and Saskatchewan, have been partly responsible for the non resumption of carbonization and briquetting operations there. Two briquetting plants are reported in operation in Alberta—one at Canmore and the other at Nordegg—the raw material briquetted being low volatile bituminous fines.

FUEL HYDROGENATION INVESTIGATIONS

The hydrogenation of coal and other fuels consists of heating them under high pressure in the presence of hydrogen and a catalyst. The reaction may take place in the solid, liquid, or gaseous state. By the hydrogenation treatment heavy liquid hydro-carbon fuels are transformed into lighter liquid fuels usually with the production of hydrocarbon and other gases. In the hydrogenation of high molecular weight petroleum, bitumen and coal tar, the aim is to produce lighter hydrocarbon oils with an average molecular weight approximating that of gasoline, with a minimum amount of solid and gaseous products. When applied to coal the objective is to produce a maximum yield of motor fuel with minimum amounts of coke and waste gases. For best heat transfer conditions coal in the pulverized state is mixed with a heavy coal tar oil and fed to the reaction chamber in the form of an emulsion or paste. In the hydrogenation reaction the solid coal particles are first converted into heavy (tar) oils and then into lighter oils, and the proper temperature and pressure conditions to obtain maximum yields of motor fuel of desired properties from a given coal are determined by experiment.

The investigational programme on fuel hydrogenation at the Fuel Research Laboratories was begun in 1929 since when it has comprised the following series of batch and continuous tests:—

*Small Laboratory Scale Tests in One Litre Bomb*

(*a*) On bitumen from Alberta bituminous sands.
(*b*) On coal tar from a Nova Scotia coal by low temperature carbonization.
(*c*) On several Canadian coals of varying rank in admixture with coal tar.

*Intermediate Scale Tests in Large (4 Litre) Bomb*

(*d*) On bitumen, coal tar and suspension of powdered coal in coal tar.

*Large Laboratory Scale Tests in New Vertical Reaction Chamber*

(*e*) On typical bituminous coals from Nova Scotia and British Columbia.

The programme outlined in (*a*), (*b*) and (*c*) which were intermediate batch tests in a small (Cook) bomb of one litre capacity, served to demonstrate the amenability to hydrogenation of the fuels tested. These tests, the detailed results of which have been published[43,44] demonstrated that both Alberta bitumen and low temperature tar from Nova Scotia coal were eminently suitable for high pressure hydrogenation. With the bitumen, laboratory yields of 65 to 75 per cent by weight, equal to 90 to 100 per cent by volume, of the unrefined gasoline fraction were obtained, in comparison with the 30 to 40 per cent by weight yield by the "Cross" pressure cracking process. Optimum results were obtained on the coal tar at approximately 450 deg. C. and 250 atmospheres pressure, using molybdic oxide as catalyst. On each material the coke formation by hydrogenation was reduced to about one-half of 1 per cent as compared with 17 per cent by ordinary pressure cracking without hydrogen. The yield of the gasoline fraction by hydrogenation was double that by pressure cracking, with total oil recoveries of 90 and 78 per cent respectively.

The intermediate scale tests[45] in a large four litre (Cook) bomb on coal tar, as per (*d*) above, were intermittent batch tests each of eight hours duration, but the apparatus was capable of continuous operation. On the three different materials tested with molybdic oxide as catalyst, the pressures of the reaction chamber ranged from 183 to 187 atmospheres with temperatures varying from 428 to 452 deg. C. The net yields of "dry volatile oil" obtained were 102 per cent by volume from the bitumen, 90 per cent from the coal tar, and 89 per cent from the coal tar-coal emulsion. These yields are based on the net material charged, that is, the total amount charged minus the partly converted oil left in the reaction chamber at the end of the run—which represents the yields that could be obtained in continuous runs of long duration. The yields from the bitumen and coal tar previously obtained in the small bomb were thus confirmed, with the conversion yield from the mixture of coal and coal tar practically equal to that of the coal tar oil. Another noteworthy result was that carbon formation was avoided in all of the three test runs and the volatile products from the three different raw materials had quite similar distillation ranges—with a 45 per cent gasoline fraction below 410 deg. F. and a 90 per cent combined gasoline and kerosene yield below 472 deg. F.

The tests in the small bomb as per (*c*) were planned for the purpose of ascertaining the relative amenability to hydrogenation of typical Canadian coals varying widely in rank. The results obtained were not entirely satisfactory, due, it was judged, to the tendency of the catalyst and other solids to settle out and form a cake in the bottom of the bomb below the paddle stirrer, thus preventing uniform heating of the charge. This effect took place particularly with the high rank semi-anthracite coal, with two lignites and with peat, all of which are non-coking. The results, however, do indicate that generally speaking the suitability of six other coals to hydrogenation was directly according to their rank classification. The highest coal-to-oil conversion, viz., 70 per cent by weight, was obtained from a medium volatile bituminous coal, with yields of 64, 51, and 46 per cent from three different high volatile bituminous coals, and of 22 and 13 per cent from a typical sub-bituminous and a domestic coal respectively. These results are of comparative value only and subject to confirmation on a larger scale.

*Continuous Hydrogenation Tests in Vertical Reaction Chamber*

For the tests referred to in (*e*) above, an apparatus with a throughput capacity of one Imperial gallon of raw material per hour is used. The main part of this apparatus, or rather equipment, consists of an externally heated vertical reaction chamber 10 feet long and 2.74 in. inside diameter, made from chrome nickel steel and equipped with temperature controller and recorder. Accessory equipment which has been described[46] in detail with illustrations, is comprised of the following pieces of apparatus, viz., on the raw material feed portion:—portable hydrogen (shipping) cylinders, three-stage compressor, two high pressure hydrogen storage cylinders, feed tank and liquid feed pump; and on the product side of the reaction chamber operated under high pressure, a cooler, receiver, hydrogen recirculating pump and flow meter. In this experimental equipment capable of operation either continuously for long periods of several days or intermittently continuous for shorter periods of eight to twelve hours, the shortcomings of the batch test runs in the autoclave bomb reaction chamber are remedied, and results more applicable to commercial conditions are obtainable.

In brief a hydrogenation test on a coal consists of mixing the pulverized coal with a heavy oil from a previous run as vehicle, and pumping the coal-oil paste into the system just prior to the reaction chamber, into which the charge is carried by the hydrogen from the high pressure storage cylinders. The current of hydrogen and other gaseous products augmented by the hydrogen recirculating pump also serves for removing the hydrogenated liquid product from the reaction chamber into the cooler and high pressure receiver, from where by a gradual reduction of pressure it is removed for subsequent examination. On a given coal a series of eight-hour test runs are necessary in order to accumulate sufficient hydrogenated heavy oil vehicle to make a final hydrogenation test on that coal. Hence allowing time for the proper examination of the products from each eight-hour test run it requires a month or longer to complete a test on a coal.

To date only three coals have been tested in the continuous vertical reaction chamber equipment, viz., on two high volatile bituminous coals, one each from Cape Breton and Vancouver Island, and on a medium volatile bituminous coal from the Crow's Nest area, British Columbia. Of these coals, which were included in the batch tests in the small bomb mentioned above, the best yields have been obtained from the one from Nova Scotia, viz., the washed coal with 3.5 per cent ash content from the Sydney area reported in Table VIII. The best results on this coal were obtained at a reaction chamber temperature of 443 deg. C. and 2,940 lb. per square inch pressure (that is 200 atmospheres). It was found that at this pressure for this particular coal slight changes in temperature and certain other operating conditions reduced the net coal-to-oil conversion yield from a maximum of over 77 per cent to less than 54 per cent.

Tabulated below are the results from the Sydney Nova Scotia coal in comparison with those from a Yorkshire coal, which shows that the yields from the English coal reported by the Imperial Chemical Industries can be closely approached on a Canadian coal in our equipment at the Fuel Research Laboratories.

Table XI

| | Per cent weight of coal charged | |
|---|---|---|
| | Yorkshire coal | Sydney, N.S. coal |
| Hydrogen used | 7.5 per cent | 7.4 per cent |
| Solid residue | 4.0 per cent | 6.2 per cent |
| Aqueous liquor | 8.0 per cent | 7.0 per cent |
| Gas produced | 15.5 per cent | 16.8 per cent |
| Oil produced | 80.0 per cent | 77.5 per cent |

Sufficient information has been obtained to show that each coal tested requires a different set of conditions for optimum results. Hence the main purpose of the hydrogenation tests now in progress is to ascertain these conditions by experimentation. It is planned to test first a series of typical coals varying widely in rank from the different eastern and western Canadian coal producing fields, after which a second series on particular coals of the rank showing the best results will be in order. Furthermore it is anticipated that several Canadian coals will be found suitable for the production of motor fuel and other (petroleum oil) products by hydrogenation.

The authors wish to acknowledge the assistance rendered in the preparation of this paper by members of the technical staff of the Division of Fuels and especially those included in the reference list following:—

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# Characteristics and Quality of Nova Scotian Coals

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SUMMARY.—Describes recent investigations on Nova Scotia coals as to their characteristics and performance when used for domestic heating and steam boiler firing. Tests of the effect of weathering on stock piles were also made.

Although extraordinarily rich in almost all other kinds of minerals, the eastern half of Canada has no coal except near the Atlantic coast. Most of the deposits of this mineral are in Nova Scotia, and are situated so close to the shore that the waves break over a good many of the outcrops. The greater portion of the beds extend out under the ocean and over half of the output is taken from under the bed of the Atlantic. Some of the working faces of the collieries are nearly three miles from the shore. It seems as though Nature had been chiefly concerned in Nova Scotia with creating the greatest fishing grounds in the world, and had grudgingly lifted only enough land to show on the beaches the outcroppings of the seams of coal that extended out under the waves. On the east and west coasts of Cape Breton island the coal beds lie exposed in the cliffs of the shore and the surf almost literally breaks at the foundations of the colliery hoisting head frames. There are two important coal fields in the interior of the mainland of Nova Scotia in Pictou and Cumberland counties, but neither is very far from tide-water.

These deposits have been worked for well over two centuries and were yielding coals before the famous Pennsylvania fields were discovered. The extent of the beds is not known nor the economic limits to which they can be exploited. It has been estimated that the province contains over two billion tons of coal in beds that are one foot or over in thickness less than four thousand feet in depth and within three miles of the shore. This actual reserve is large enough to supply coal at the present rate of production for more than three hundred years. Most of the seams lie in the rocks of the Upper Carboniferous and are all classified as bituminous coal. Almost all the fuel requirements of the Maritime Provinces, Quebec, and Newfoundland are supplied from these areas because of the ease and economy of transportation by water. Large steamers can carry cargoes up the St. Lawrence as far as Montreal. At this point begins a severe competition with coal carried by rail or rail and water from Pennsylvania, West Virginia, and Ohio, all of which lie not far south of Ontario. That province imports far more bituminous coal from the United States than the entire production of Nova Scotia.

In recent years the Dominion Government has become increasingly conscious of the national importance of maintaining the coal mining industry of the eastern provinces in a reasonably healthy condition. There has also grown up a better feeling on the part of the highly industrialized central provinces in respect to a responsibility for purchasing fuel from the east as a partial compensation for the large sales of manufactured articles there. There have been established federal subventions to the railroads for payment of freight charges to equalize the prices of coal from the Maritimes in Quebec and Ontario with those from the United States. This has led to a slow but steady increase in the production of Nova Scotian coal with satisfactory related economic advantages to Canada. No one can predict how far or how fast this movement will proceed because there are so many sudden changes that disturb the equilibrium in the central Canadian coal market and also other factors such as, (1) the increasing use of oil for fuel and power, (2) the greater efficiencies obtained from the combustion of coal in the more modern plants, and (3) the wider use of energy generated from hydro-electric plants.

During the past few years great advances have been made in the production of steam power from coal. The improvements in efficiencies from pulverization, higher pressures, greater ratings, better mechanical stokers and boiler accessories, and other changes in practice are well known to all engineers. Increasing costs of raw coal and competition from power manufactured in hydro-electric plants have been generally met so that steam still holds its dominant position in this field. When new stations are now built or additions made to existing plants, the problem of securing the most economical fuel and equipment for the special conditions to be met is one which involves the most careful analysis and engineering design. After the fuel which will be used has been selected, the apparatus to be installed is often modified largely in order to secure the best results.

In the light of these existing conditions it becomes necessary for a coal-producing area to have available all the scientific and technical data concerning the fuels which it markets so that the combustion engineer may give them full consideration for use in plants where they are available. This is especially true with Nova Scotian coals, which are shipped to inland points nearly 1,000 miles away from the mines to meet competition with the American coals from Pennsylvania and West Virginia. The data on the fuels mined in eastern Canada were comparatively meagre and scattered through many publications. From 1906 to 1910 a thorough investigation had been carried out by the Dominion Department of Mines on Canadian coals and the results published.[1] Since that time, however, the working faces of the mines in Nova Scotia had been advanced for miles in some cases and the data in this report referred to coal which had long been extracted. The figures could not be used by the combustion engineer who wished to know what kinds of coal were available in the market when he was planning his plant for present use.

These facts led the Nova Scotian government in 1928 to carry out a fresh investigation into the characteristics and qualities of the coal being produced in the province. An advisory board was created which included representatives of the two Canadian railway systems, the coal-producing companies, practising combustion engineers, members of the staff of the Federal Department of Mines, and professors from the Nova Scotia Technical College. A programme of action was planned and carried out during the years 1928 to 1931.

The complete results have been published in the annual report of the Nova Scotia Department of Public Works and Mines for the year 1933.

The programme included four distinct branches of effort:

1. Chemical analyses on representative samples taken directly from the working faces in the producing collieries throughout the province.
2. Evaporation tests in standard boiler trials of large-scale samples taken from the working faces.
3. Radiation tests in common types of domestic hot-water boilers to ascertain comparative heating values between fuels produced locally and imported fuels.

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[1]J. B. Porter and R. J. Durley: An Investigation of the Coals of Canada, 1912, six volumes, Dept. of Mines, Ottawa.

4. Weathering characteristics of Nova Scotian bituminous coals when stored in stock piles.

### Chemical Analyses of Nova Scotian Coals

In each mine two separate samples were taken from the working face. One was from a channel, three inches deep and four inches wide, cut by hand from the roof to the floor. All splint and pyritic bands such as would be removed on a picking belt were rejected and the coal placed immediately in air-tight cans. At the same spot a large 5-ton sample was taken which was bagged and shipped to the Technical College for boiler trials. This latter sample was again cut down and analyzed after it had arrived at its destination.

The laboratory work included the following determinations:

1. Proximate analysis for moisture, volatile matter, fixed carbon, and ash.
2. Ultimate analysis for carbon, hydrogen, oxygen, nitrogen, and sulphur.
3. Calorific power.
4. Fusibility of ash.

The methods followed were those which had been set forth as standards by the American Society for Testing Materials. The calorific values were determined by means of an Emerson-Daniels oxygen-bomb adiabatic calorimeter. The analyses are reported on the "as received" and "moisture-free" bases. The letters "R" and "D" respectively refer to the samples in these conditions.

The results of the analyses included here are limited to those mines in the three areas of Sydney, Pictou, and Springhill from which considerable amounts are exported to other provinces. Coal from the other mines is mostly consumed in Nova Scotia.

The samples selected are as shown in the following tabulation:

Table I

| No. | Mine | Coal seam | Area |
|---|---|---|---|
| 1-16-01 | No. 16 | Lingan | Sydney |
| 1-1B-02 | No. 1B | Phalen | Sydney |
| 1-02-03 | No. 2 | Phalen | Sydney |
| 1-04-04 | No. 4 | Phalen | Sydney |
| 1-11-06 | No. 11 | Emery | Sydney |
| 1-Pr-07 | Princess | Main | Sydney |
| 1-Fl-08 | Florence | Main | Sydney |
| 4-24-16 | Albion | Third | Pictou |
| 4-24-17 | Albion | Cage-pit | Pictou |
| 4-22-12 | McGregor | McGregor | Pictou |
| 4-22-13 | McGregor | Fleming | Pictou |
| 4-23-15* | Allan | Foord | Pictou |
| 4-23-16* | Allan | Foord | Pictou |
| 4-23-17* | Allan | Foord | Pictou |
| 4-23-18* | Allan | Foord | Pictou |
| 5-02-22 | No. 2 | | Springhill |
| 5-06-20 | No. 6 | | Springhill |
| 5-07-21 | No. 7 | | Springhill |

*The four samples, 4-23-15 to 4-23-18, were taken from the Foord seam which is 40 ft. thick and each sample represents a 10-ft. section progressing with the successive numbers from roof to floor. Each of these was a 5-ton sample.

It is interesting to note the variations in composition in the four samples taken from the 40-ft. Foord seam in the Pictou area. The differences between 10-ft. sections are greater than in the case of coal samples taken from different mines in the Sydney area.

If the analyses of the channel samples are carefully compared with those of the 5-ton samples, it will be seen that the former indicate a slightly better coal in most cases. This is probably due to the care with which impurities such as splint and pyrite are discharged when cutting the channel by hand. The coal as mined is not picked so carefully although the sampler tries to simulate closely the regular rejections that would take place on the picking belt. The results secured in the analyses of the 5-ton lots would approximate the constitution of the run-of-mine coal as marketed in large quantities more closely than would those obtained from the channel samples.

The fusibility of the ash has become an important value in recent years, especially where the fuel is being considered for use in high boiler ratings. Most of the coals in the Sydney area have ashes that are classed as easily fusible. The Springhill coals are better in this characteristic and have ashes that are designated as of medium fusibility. The Pictou coals show a still higher temperature of ash fusibility and that from the Foord seam is almost up to the refractory level.

### Comparative Tests of Fuels in Domestic Hot-water Heating Boilers

The purpose of these tests was to find the relative values of various fuels that were commonly used in Nova Scotia for house-heating in the winter months. Not many years ago most homes used Pennsylvania anthracite for this purpose. The price of this coal steadily advanced and caused people to turn to other forms of fuel. Coke from gas works and by-product ovens, sized bituminous coal, and briquettes came to be widely used. With the wide distribution of electrical power at low prices many small stokers were developed for household use and an even wider range of fuels was employed. Furnace design was improved concurrently so that even for domestic heating the small sizes of anthractie were successfully burned. Oil burners with blowers and regulating thermostats were put on the market for those people who were willing to pay a higher cost for the extra convenience and close temperature control. All this has led to new practices of coal producers in the careful preparation of a wide variety of fuels to meet the demands of the users. In eastern Canada the imports of anthracites in small sizes from Great Britain has largely increased in recent years. This movement has spurred the coal operators of Nova Scotia to new efforts to meet the competition by promoting the use of metallurgical coke, by offering more closely sized soft coal, and by sponsoring certain types of mechanical apparatus and furnaces suitable for the efficient burning of coke and bituminous coal in house-heating.

The householder himself has become more acutely aware of the scientific and economic aspects of the problem of keeping warm during the winter, and is keenly interested in the apparatus and the fuel he should use to procure the best result with the maximum of convenience he can afford. Under these conditions it seemed the part of wisdom for the provincial government to conduct some tests in regard to the relative heating values of the common solid fuels available, in order to supply information to the householders on how to solve their heating problems. It was hoped that the results would show that the economic advantages would be in favour of using local soft coals or the cokes manufactured from them. Accordingly, authority was given to carry out a series of trials on domestic hot-water boilers at the Nova Scotia Technical College.

In 1925 the testing laboratories of the Mines Branch of the Federal Department of Mines had conducted an elaborate series of tests[2] of this nature. The fuels used included Welsh, Scotch, and American anthracites, gas coke, by-product coke, American and Alberta semi-bituminous, and Alberta bituminous. Nova Scotian coals were not included in this programme. It was thought best to carry out the local investigation as closely as possible with apparatus and procedure followed by the workers in Ottawa so that the results obtained would be closely comparable.

[2]Results reported in Mines Branch Investigations of Fuels and Fuel Testing, 1925, Bulletin No. 671, pp. 33-63.

### Table II-A
Chemical Analyses of Samples

| Item No. | Sample No. 1-16-01 | | | | Sample No. 1-1B-02 | | | | Sample No. 1-02-03 | | | | Sample No. 1-04-04 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Channel | | 5-ton | | Channel | | 5-ton | | Channel | | 5-ton | | Channel | | 5-ton | |
| | R | D | R | D | R | D | R | D | R | D | R | D | R | D | R | D |
| Proximate analysis | | | | | | | | | | | | | | | | |
| 1. Moisture.............per cent | 3.6 | | 2.8 | | 1.9 | | 1.5 | | 2.1 | | 2.0 | | 1.6 | | 1.5 | |
| 2. Volatile matter........per cent | 32.4 | 33.6 | 33.0 | 34.0 | 33.8 | 34.5 | 33.9 | 34.4 | 32.9 | 33.6 | 32.0 | 32.6 | 33.5 | 34.0 | 33.7 | 34.2 |
| 3. Fixed carbon..........per cent | 58.2 | 60.4 | 57.9 | 59.6 | 57.7 | 58.8 | 58.0 | 58.9 | 57.2 | 58.4 | 57.0 | 58.2 | 56.0 | 56.9 | 57.8 | 56.7 |
| 4. Ash..................per cent | 5.8 | 6.0 | 6.3 | 6.4 | 6.6 | 6.7 | 6.6 | 6.7 | 7.8 | 8.0 | 9.0 | 9.2 | 8.9 | 9.1 | 7.0 | 7.1 |
| Ultimate analysis | | | | | | | | | | | | | | | | |
| 5. Carbon...............per cent | 77.0 | 79.9 | 79.7 | 78.9 | 76.2 | 77.7 | 76.4 | 77.6 | 77.3 | 79.0 | 75.2 | 76.7 | 75.1 | 76.3 | 77.7 | 78.9 |
| 6. Hydrogen............per cent | 6.0 | 6.0 | 5.3 | 5.1 | 5.4 | 5.3 | 5.3 | 5.2 | 5.3 | 5.2 | 5.2 | 5.1 | 5.2 | 5.1 | 5.4 | 5.3 |
| 7. Ash..................per cent | 5.8 | 5.8 | 6.3 | 6.4 | 6 6 | 6.7 | 6.6 | 6.7 | 7.8 | 8.0 | 9.0 | 9.2 | 8.9 | 9.1 | 7.0 | 7.1 |
| 8. Sulphur..............per cent | 2.2 | 2.2 | 2.2 | 2.3 | 3.3 | 3.3 | 3.7 | 3.7 | 3.5 | 3.6 | 4.5 | 4.6 | 5.1 | 5.2 | 3.6 | 3.7 |
| 9. Nitrogen.............per cent | 1.3 | 1.4 | 1.4 | 1.5 | 1.3 | 1.4 | 1.4 | 1.4 | 1.4 | 1.5 | 1.5 | 1.5 | 1.3 | 1.3 | 1.4 | 1.4 |
| 10 Oxygen...............per cent | 7.7 | 4 7 | 8 1 | 5 8 | 7.2 | 5.6 | 6.6 | 5.4 | 4.7 | 2.7 | 4.6 | 2.9 | 4.4 | 3.0 | 4.9 | 3.6 |
| Calorific value | | | | | | | | | | | | | | | | |
| 11. B.t.u. per lb.................. | 13,810 | 14,330 | 13,700 | 14,120 | 13,850 | 15,125 | 14,010 | 14,225 | 13,750 | 14,050 | 13,750 | 13,840 | 13,515 | 13,745 | 13,990 | 14,210 |
| 12. Fuel ratio F.C./V.M.......... | 1.8 | | 1.8 | | 1.7 | | 1.7 | | 1.7 | | 1.8 | | 1.7 | | 1.7 | |
| Fusibility of ash | | | | | | | | | | | | | | | | |
| 13. Deformation temp......deg. F. | 1,965 | | 1,970 | | 1,930 | | 1,940 | | 1,930 | | 1,980 | | 1,950 | | 1,980 | |
| 14. Softening temp.........deg. F. | 2,005 | | 2,005 | | 1,960 | | 1,980 | | 1,950 | | 2,000 | | 1,970 | | 2,000 | |
| 15. Fluid temp............deg. F. | 2,025 | | 2,030 | | 1,995 | | 2,020 | | 1,980 | | 2,040 | | 2,005 | | 2,040 | |

### Table II-B
Chemical Analyses of Samples

| Item No. | Sample No. 1-11-06 | | | | Sample No. 1-Pr-07 | | | | Sample No. 1-Fl-08 | | | | Sample No 4-24-16 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Channel | | 5-ton | | Channel | | 5-ton | | Channel | | 5-ton | | Channel | | 5-ton | |
| | R | D | R | D | R | D | R | D | R | D | R | D | R | D | R | D |
| Proximate analysis | | | | | | | | | | | | | | | | |
| 1. Moisture.............per cent | 4.2 | | 2.9 | | 3.3 | | 2.4 | | 4.2 | | 3.3 | | 2.6 | | 2.5 | |
| 2. Volatile matter........per cent | 33.7 | 35.2 | 34.7 | 35.7 | 37.9 | 39.2 | 39.2 | 40.2 | 37.9 | 39.6 | 37.7 | 33.9 | 29.5 | 30.2 | 28.7 | 29.4 |
| 3. Fixed carbon..........per cent | 55.2 | 57.6 | 52.7 | 54.3 | 53.1 | 54.9 | 52.1 | 53.4 | 52.6 | 54.9 | 52.5 | 54.3 | 56.3 | 57.8 | 56.3 | 57.7 |
| 4. Ash..................per cent | 6.9 | 7.2 | 9.7 | 10.0 | 5.7 | 5.9 | 6.3 | 6.5 | 5.3 | 5.5 | 6.5 | 6.8 | 11.6 | 12.0 | 12.5 | 12.9 |
| Ultimate analysis | | | | | | | | | | | | | | | | |
| 5. Carbon...............per cent | 74.7 | 78.0 | 73.5 | 75.7 | 75.5 | 78.1 | 76.2 | 78.1 | 74.8 | 78.1 | 74.3 | 76.8 | 72.1 | 74.0 | 71.5 | 73.4 |
| 6. Hydrogen............per cent | 5.5 | 5.2 | 5.3 | 5.1 | 5.7 | 5.5 | 6.0 | 5.9 | 5.6 | 5.3 | 5.5 | 5.3 | 4.9 | 4.7 | 4.7 | 4.5 |
| 7. Ash..................per cent | 6.9 | 7.2 | 9.7 | 10.0 | 5.7 | 5.9 | 6.3 | 6.5 | 5.3 | 5.5 | 6.5 | 6.8 | 11.6 | 12.0 | 12.5 | 12.9 |
| 8. Sulphur..............per cent | 2.5 | 2.6 | 2.5 | 2.5 | 3.5 | 3.6 | 4.1 | 4.2 | 3.0 | 3.1 | 3.6 | 3.8 | 1.3 | 1.4 | 1.2 | 1.2 |
| 9. Nitrogen.............per cent | 1.4 | 1.5 | 1.4 | 1.5 | 1.7 | 1.7 | 1.6 | 1.6 | 1.7 | 1.8 | 1.6 | 1.7 | 2.1 | 2.1 | 2.0 | 2.0 |
| 10. Oxygen...............per cent | 9.0 | 5.5 | 7.6 | 5.2 | 7.9 | 5.2 | 5.8 | 5.7 | 9.6 | 6.2 | 8.5 | 5.6 | 8.0 | 5.8 | 8.1 | 6.0 |
| Calorific value | | | | | | | | | | | | | | | | |
| 11. B.t.u. per lb.................. | 13,280 | 13,970 | 13,010 | 13,400 | 13,770 | 14,230 | 13,780 | 14,125 | 13,515 | 14,115 | 13,440 | 13,900 | 12,692 | 13,026 | 12,513 | 12,840 |
| 12. Fuel ratio F.C./V.M.......... | 1.6 | | 1.5 | | 1.4 | | 1.3 | | 1.4 | | 1.4 | | 1.9 | | 2.0 | |
| Fusibility of ash | | | | | | | | | | | | | | | | |
| 13. Deformation temp......deg. F. | 1,990 | | 2,025 | | 2,010 | | 2,100 | | 2,070 | | 1,950 | | 2,200 | | 2,300 | |
| 14. Softening temp.........deg. F. | 2,040 | | 2,070 | | 2,070 | | 2,125 | | 2,090 | | 2,030 | | 2,300 | | 2,300 | |
| 15. Fluid temp............deg. F. | 2,080 | | 2,100 | | 2,110 | | 2,150 | | 2,120 | | 2,060 | | | | | |

### Table II-C
Chemical Analyses of Samples

| Item No. | Sample No. 4-24-17 | | | | Sample No. 4-22-12 | | | | Sample No. 4-22-13 | | | | Sample No. 4-23-15 | | Sample No. 4-23-16 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Channel | | 5-ton | | Channel | | 5-ton | | Channel | | 5-ton | | | | | |
| | R | D | R | D | R | D | R | D | R | D | R | D | R | D | R | D |
| Proximate analysis | | | | | | | | | | | | | | | | |
| 1. Moisture.............per cent | 2.8 | | 2.8 | | 2.1 | | 2.0 | | 1.8 | | 1.7 | | 1.6 | | 1.5 | |
| 2. Volatile matter .......per cent | 29.5 | 30.3 | 30.8 | 31.7 | 29.4 | 30.0 | 29.1 | 29.7 | 29.4 | 29.9 | 29.4 | 29.9 | 30.0 | 30.8 | 31.0 | 31.5 |
| 3. Fixed carbon..........per cent | 57.3 | 59.0 | 55.3 | 56.9 | 57.6 | 58.9 | 57.8 | 58.9 | 55.4 | 56.9 | 54.4 | 55.3 | 56.7 | 57.6 | 57.9 | 58.8 |
| 4. Ash..................per cent | 10.4 | 10.7 | 11.1 | 11.4 | 10 9 | 11.1 | 11.1 | 11.4 | 12.9 | 13.2 | 14.5 | 14.8 | 11.4 | 11.6 | 9.6 | 9.7 |
| Ultimate analysis | | | | | | | | | | | | | | | | |
| 5. Carbon...............per cent | 72.8 | 75.0 | 72.2 | 74.2 | 73.5 | 75.1 | 73.7 | 75.1 | 71.9 | 73.2 | 70.7 | 71.9 | 74.1 | 75.2 | 76.4 | 77.5 |
| 6. Hydrogen............per cent | 5.1 | 4.9 | 4.8 | 4.6 | 4.9 | 4.7 | 4.8 | 4.7 | 4.8 | 4.7 | 4.4 | 4.3 | 5.1 | 5.0 | 5.5 | 5.4 |
| 7. Ash..................per cent | 10.4 | 10.7 | 11.1 | 11.4 | 10.9 | 11.1 | 11.1 | 11.4 | 12.9 | 13.2 | 14.5 | 14.8 | 11.4 | 11.6 | 9.6 | 9.7 |
| 8. Sulphur..............per cent | 1.0 | 1.0 | 0.9 | 1.0 | 1.1 | 1.1 | 1.3 | 1.4 | 1.1 | 1.1 | 1.3 | 1.4 | 1.0 | 1.0 | 0.7 | 0.8 |
| 9. Nitrogen.............per cent | 2.2 | 2.2 | 2.2 | 2 3 | 2 0 | 2.1 | 2.1 | 2.1 | 2.0 | 2.0 | 2.0 | 2.0 | 2.4 | 2.5 | 2.5 | 2.6 |
| 10. Oxygen...............per cent | 8.5 | 6.2 | 8.8 | 6.5 | 7.6 | 5.9 | 7.0 | 5.3 | 7.3 | 5.8 | 7.1 | 5.6 | 6.0 | 4.7 | 5.3 | 4.0 |
| Calorific value | | | | | | | | | | | | | | | | |
| 11. B.t.u. per lb.................. | 12,776 | 13,145 | 12,650 | 13,020 | 12,820 | 13,090 | 12,940 | 13,190 | 12,490 | 12,720 | 12,380 | 12,590 | 13,340 | 13,550 | 13,600 | 13,810 |
| 12. Fuel ratio F.C./V.M.......... | 2.0 | | 1.8 | | 2.0 | | 2.0 | | 1.9 | | 1.8 | | 1.9 | | 1.9 | |
| Fusibility of ash | | | | | | | | | | | | | | | | |
| 13. Deformation temp......deg. F. | 2,335 | | 2,150 | | 2,250 | | 2,120 | | 2,220 | | 2,000 | | 2,450 | | 2,260 | |
| 14. Softening temp.........deg. F. | 2,378 | | 2,335 | | 2,370 | | 2,190 | | 2,278 | | 2,210 | | 2,600 | | 2,420 | |
| 15. Fluid temp............deg. F. | | | 2,390 | | | | | | | | 2,290 | | | | | |

Table II-D
Chemical Analyses of Samples

| Item No. | Sample No. 4-23-17 | | Sample No. 4-23-18 | | Sample No. 5-02-22 | | | | Sample No. 5-06-20 | | | | Sample No. 5-07-21 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Channel | | 5 ton | | Channel | | 5-ton | | Channel | | 5-ton | |
| | R | D | R | D | R | D | R | D | R | D | R | D | R | D | R | D |
| Proximate analysis | | | | | | | | | | | | | | | | |
| 1. Moisture............per cent | 1.5 | | 1.5 | | 2.1 | | 2.5 | | 3.0 | | 2.9 | | 3.9 | | 2.6 | |
| 2. Volatile matter........per cent | 29.2 | 29.6 | 30.8 | 31.2 | 32.3 | 33.0 | 31.9 | 32.7 | 31.1 | 34.1 | 33.0 | 34.0 | 33.3 | 34.6 | 33.7 | 34.6 |
| 3. Fixed carbon..........per cent | 53.9 | 54.7 | 55.3 | 56.2 | 60.1 | 61.4 | 58.1 | 59.6 | 57.4 | 59.2 | 56.9 | 58.6 | 56.9 | 59.6 | 55 9 | 57.4 |
| 4. Ash..................per cent | 15.4 | 15.7 | 12.4 | 12.6 | 5.5 | 5.6 | 7.5 | 7.7 | 6.5 | 6.7 | 7.2 | 7.4 | 5.9 | 6.2 | 7.8 | 8.0 |
| Ultimate analysis | | | | | | | | | | | | | | | | |
| 5. Carbon...............per cent | 70.6 | 71.7 | 74.2 | 75.3 | 78.7 | 80.4 | 77.2 | 79.1 | 75.0 | 77.4 | 75.3 | 77.6 | 74.6 | 77.6 | 74.6 | 76.6 |
| 6. Hydrogen............per cent | 4.8 | 4.7 | 5.0 | 5.0 | 5.6 | 5.4 | 5.5 | 5.4 | 5.8 | 5.7 | 5.6 | 5.4 | 5.6 | 5.4 | 5.4 | 5.3 |
| 7. Ash..................per cent | 15.4 | 15.7 | 12.4 | 12.6 | 5.5 | 5.6 | 7.5 | 7.7 | 6.5 | 6.7 | 7.2 | 7.4 | 5.9 | 6.2 | 7.8 | 8.0 |
| 8. Sulphur.............per cent | 1.1 | 1.1 | 0.8 | 0.8 | 0.9 | 1.0 | 1.0 | 1.1 | 1.6 | 1.6 | 1.6 | 1.7 | 1.6 | 1.7 | 1.5 | 1.6 |
| 9. Nitrogen.............per cent | 2.1 | 2.1 | 2.2 | 2.2 | 2.1 | 2.1 | 2.0 | 2.1 | 2.2 | 2.3 | 2.3 | 2.4 | 2.1 | 2.2 | 2.3 | 2.4 |
| 10. Oxygen..............per cent | 6.0 | 4.7 | 5.4 | 4.1 | 7.2 | 5.5 | 6.8 | 4.6 | 8.9 | 6.3 | 9.0 | 5.5 | 10.2 | 6.9 | 9.4 | 6.1 |
| Calorific value | | | | | | | | | | | | | | | | |
| 11. B.t.u. per lb.................. | 12,580 | 12,770 | 13,190 | 13,380 | 14,000 | 14,400 | 13,580 | 14,030 | 13,450 | 13,880 | 13,380 | 13,780 | 13,290 | 13,840 | 13,190 | 13,550 |
| 12. Fuel ratio F.C./V.M.......... | 1.8 | | 1.8 | | 1.9 | | 1.8 | | 1.7 | | 1.7 | | 1.7 | | 1.7 | |
| Fusibility of ash | | | | | | | | | | | | | | | | |
| 13. Deformation temp......deg. F. | | | 2,250 | | 2,255 | | | | 2,066 | | | | 2,058 | | | |
| 14. Softening temp.........deg. F. | 2,500+ | | 2,335 | | 2,295 | | | | 2,096 | | | | 2,078 | | | |
| 15. Fluid temp............deg. F. | | | 2,500 | | 2,370 | | | | 2,224 | | | | 2,140 | | | |

The boilers used for domestic hot-water heating systems were the ones selected for the trials, because this kind lent itself best to securing the most accurate results and this type of heating is used widely throughout the province. Three common types of hot-water boilers were installed for the investigation, known in the trade as the horizontal-section, vertical-section, and drop-tube. The last mentioned form is designed for using bituminous coal and is not as widely employed as the two preceding ones, so that it was not used to any great extent in the tests. The size of the furnace is that which is usually provided to heat a house of eight rooms.

The method of firing in the boiler followed closely the practice of the householder in maintaining heat in his home. The furnace was run for a period until a good fire bed had been formed and the rate of combustion approximated that of the test. This brought all the parts of the heating system to a stable working condition. At the actual beginning of tests, the grates were shaken and a charge of fresh fuel fired that would last from four to ten hours according to the kind that was being used. At the end of the run the fire bed was brought to approximately the same condition as at the commencement.

Natural draft was used in all trials and the drafts were altered only to maintain a steady rate of combustion. Most of the tests were conducted so that 50,000 to 70,000 B.t.u. per hour were delivered to the cooling water. In some trials the rate was increased to 100,000 B.t.u. or more per hour for experimental reasons. The grates were shaken when necessary to maintain a good fire except in the case of metallurgical coke made by the Dominion Steel and Coal Corporation, with which another method known as the "still-grate" practice was found to give better results.

Preliminary tests indicated that reliable results could be secured by runs in which 500 lb. or more of the fuel were burned if the rate of combustion was not pushed above 100,000 B.t.u. per hour.

The fuels were all carefully sampled and analyzed chemically, both by the proximate and ultimate methods, and are reported on the dry basis. The refuse of ash and clinker from each trial was also sampled and the amount of combustible material retained was determined by analysis.

In the trials it was found that the best results in the use of Dosco metallurgical coke could be secured by the "still-grate" method. The grates were not shaken at all during the run and any clinker formed was lifted out through the fire door with tongs. Any ash that fell through the grate was put back on top of the fire bed after fresh fuel had been charged. In this way the ash was kept at a minimum and the method is one that can be easily followed in practice by any householder. It keeps the refuse to a small quantity and reduces the amount of combustible matter retained by the ash and clinker to a very small proportion.

### The Experimental Plant

Figure 1 shows the arrangement of the apparatus and measurements used in the investigation. The layout of the equipment is easily understood by reference to the following explanation of the meaning of the letters on the diagram.

A —Drop-tube boiler
B —Horizontal-section boiler
C —Vertical-section boiler
D —Receiving tank
E —Main weighing tank
F —Auxiliary weighing tank
G —Radiation tank
H —Radiators
J —Flue to chimney
K —Boiler flue connections
L —Riser to radiation tank
M—Return from radiation tank
N —City water supply
O —Water meter
P —Cooling water inlet
Q —Cooling water outlet to weighing tanks
R —Cooling water inlet and temperature recorder
S —Room temperature recorder
T —Tag mono carbon dioxide recorder
U —Draft gauge
V —Flue temperature pyrometer
W—Flue-gas sampling tube
X —Copper-pipe connections to flue
Y —Leads to boiler-flue connections.

The three types of boiler used in the trials are distinctly different in their design and construction. They are rated in the trade according to the number of square feet of radiator surface which they are supposed to serve efficiently. The vertical two-pass boiler has a rating of 750 sq. ft. with a grate area of 3.305 sq. ft.; the horizontal-section furnace has a rating of 1,025 sq. ft. with a grate area of 3.34 sq. ft.; and the drop-tube boiler has a rating of 1,100 sq. ft. with a grate area of 5.32 sq. ft. The first two types are widely distributed throughout Nova Scotia. All the furnaces were thoroughly lagged to diminish the amount of heat radiated from the walls.

Close to the back of the flue damper a high-range thermometer was inserted to measure the temperature of the flue gases. At the same point a sampling tube was joined through which a constant flow of flue gases was maintained for a number of hours to a sampling tank. Gas samples were analyzed for carbon dioxide, oxygen, carbon monoxide, and nitrogen by means of a Hays Orsat apparatus. In addition a Tag Mono carbon dioxide analyzer was connected to give a continuous record of the amount of this gas throughout each trial. An Ellison draft gauge furnished the means of reading the chimney draft with various damper adjustments to maintain this factor as nearly constant as possible during a test.

The water in the boilers was piped to the radiation tank above which contained nine cast iron radiators with a heating surface of 9 sq. ft. each and connected in parallel. The cooling water was supplied from the city service. The temperatures at the inlet and outlet were continuously recorded by a Tycos double-pen instrument which was frequently checked by a mercury thermometer. The amount of cooling water from the outlet of the radiation tank was all weighed. A water meter was used for this purpose in preliminary trials, but it was found to be too difficult to keep it in adjustment so that its readings could be relied upon. The radiation tank was thoroughly insulated to keep this source of heat loss to a minimum. In each trial the flow of water was closely adjusted to produce a constant temperature difference between the cooling water and the outside air.

### Fuels Tested

The different fuels tested were mostly of the varieties available to the householders in Nova Scotia. For the sake of closer comparison with the results of the domestic hot-water boiler trials made in Ottawa by the Federal Department of Mines, a few tests were made on La Salle by-product coke which is manufactured in Montreal. In all cases except this, the fuels were purchased from or donated by local dealers. There follows a list of the variety of the fuels used in these trials.

1. Gas coke manufactured by the Nova Scotia Light and Power Company, Limited, Halifax, Nova Scotia, by the horizontal retort process from Nova Scotian coal for gas utility purposes.
2. Dosco coke manufactured by the Dominion Steel and Coal Corporation, Limited, Sydney, Nova Scotia, in by-product ovens.
3. Scotch semi-anthracite.
4. Welsh anthracite.
5. Pennsylvania anthracite.
6. Nova Scotian bituminous coal, "Acadia" run-of-mine, produced by the Nova Scotia Steel and Coal Company, Limited, at Stellarton, Pictou County, Nova Scotia.
7. Nova Scotian bituminous coal, "Springhill" run-of-mine, produced by the Dominion Steel and Coal Corporation, Limited, at Springhill, Cumberland County, Nova Scotia.
8. English coke imported from Great Britain.
9. La Salle coke produced in Montreal, Quebec, in vertical by-product ovens from American bituminous coal.

The chemical constitution of the fuels on a dry basis is given in Table III.

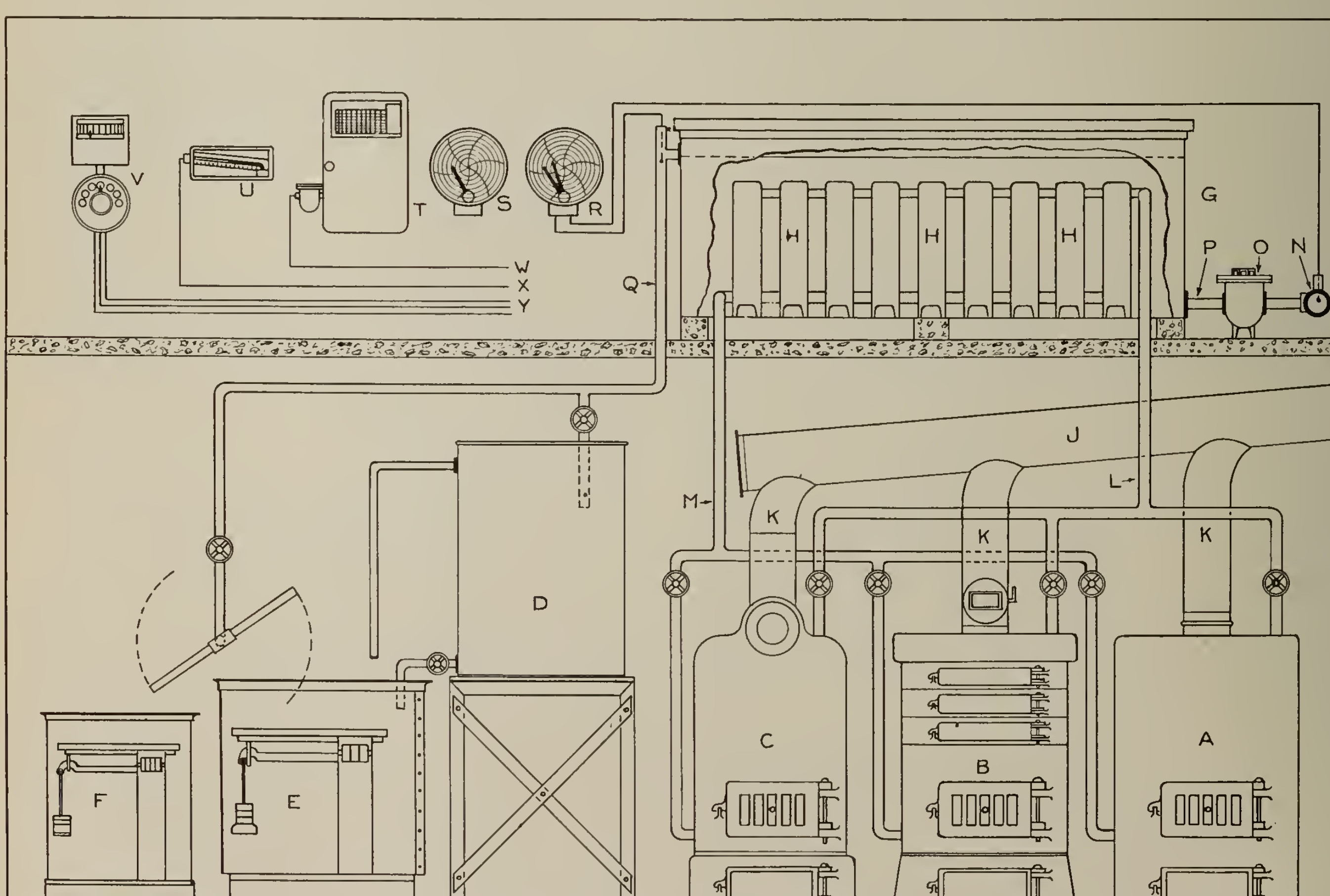


**Fig. 1—The Experimental Plant.**

Table III
Chemical Analyses

| Item No. | Gas coke | Dosco coke | Scotch anthracite | Welsh anthracite | Pennsylvania anthracite | Acadia run-of-mine | Springhill run-of-mine | English coke | LaSalle coke |
|---|---|---|---|---|---|---|---|---|---|
| Proximate Analysis | | | | | | | | | |
| Volatile matter....per cent | 2.65 | 2.88 | 9.14 | 7.80 | 6.95 | 29.90 | 33.96 | 2.0 | 1.01 |
| Fixed carbon....per cent | 90.65 | 89.29 | 84.78 | 87.30 | 82.11 | 57.46 | 58.60 | 90 2 | 90.36 |
| Ash....per cent | 6.70 | 7.83 | 6.08 | 4.90 | 10.94 | 12.64 | 7.44 | 7.8 | 8.63 |
| Ultimate analysis | | | | | | | | | |
| Carbon....per cent | 89.6 | 87.42 | 86.06 | 88.14 | 82.37 | 73.35 | 77.57 | 88.0 | 85.36 |
| Hydrogen....per cent | 0.9 | 1.10 | 3.29 | 3.54 | 2.71 | 4.77 | 5.39 | 0.6 | 0.46 |
| Oxygen....per cent | 0.0 | 1.10 | 1.89 | 0.77 | 2.14 | 6.14 | 5.53 | 1.9 | 3.76 |
| Nitrogen....per cent | 1.5 | 0.69 | 1.84 | 1.35 | 1.06 | 2.17 | 2.38 | 1.0 | 0.57 |
| Sulphur....per cent | 1.3 | 1.86 | 0.84 | 1.25 | 0.78 | 0.93 | 1.69 | 0.7 | 0.72 |
| Calorific value | | | | | | | | | |
| B.t.u. per lb.... | 13,120 | 13,170 | 13,990 | 14,450 | 13,405 | 12,956 | 13,776 | 13,290 | 13,115 |

## Results of the Trials

The most significant figure secured in the investigation was the amount of dry fuel fired per therm* delivered to the cooling water. The overall thermal efficiency gives a fair indication of the comparative values of the various fuels for heating purposes, but closer valuations may be made by using the dry fuel per therm. The salient characteristics of the different fuels tested in the boilers are shown in Table IV.

The horizontal-section boiler shows greater efficiency in burning all the fuels except one than the vertical-section type. The drop-tube furnace is best adapted for the use of bituminous coal with a fairly high percentage of volatile matter and its performance in this case excels that of the other two.

Dosco by-product coke compares favourably with the imported anthracites in the amount of heat delivered per pound of dry fuel as well as in its rating on the basis of thermal efficiency. It has advantages over Pennsylvania anthracite in that it produces only about one-third of the refuse and this is in the form of a solid heavy clinker that is easily disposed of by the householder. The American fuel gives a large volume of dusty ash which is disagreeable to handle and contains a good deal of unburned carbon. The coke ignites easily and responds quickly to changes of draft when it is desired to force or check the fire. The coke is sold at a much lower price and thus seems to possess such advantages from nearly all standpoints that it should displace the imported anthracites for domestic heating purposes.

The Nova Scotian bituminous coals can be secured at such prices that the householder can heat his home with these at less cost if he is willing to sacrifice some convenience that is available in using coke or anthracite. The furnace fire needs more frequent attention when soft coal is employed, and the interior sections of the furnace must be cleaned oftener to remove soot and dust. Acadia run-of-mine has a comparatively high percentage of ash which is disagreeable to handle. In Nova Scotia the bituminous coals are used successfully for domestic heating in the neighbourhood of the mines, but outside of these areas the imported and prepared fuels are most commonly employed. Anthracite has dominated the market for many years in the past and the home owner has become accustomed to the practice needed to get good results from it. The burning of coke requires a totally different technique and this is a handicap to its more rapid acceptance. People are becoming more concerned in improvements and economies in the heating of homes and are more amenable to experimenting with new methods and fuels.

The results of these trials are directly in line with those secured by the Dominion Department of Mines in its testing laboratories in Ottawa. They both point clearly to the advantages of replacing imported anthracite by coke which is manufactured in Canada. Hard coal is used widely in Ontario and Quebec for house-heating, and enormous quantities of this fuel are imported for this purpose. The impetus gained from long habit makes a change difficult, but the economic advantages to the individual and to the nation by using a fuel prepared in Canada are so evident that this should be a great influence toward changing over to coke for domestic heating. There has been a good deal of experimental work and development in the effort to make a small automatic stoker that will burn low grades of bituminous coal in the home under automatic thermostatic control. Progress is being made in this direction, and when satisfactory apparatus is available for a reasonable cost the use of both anthracite and coke may be sharply curtailed in house-heating.

*One therm = 100,000 B.t.u.

Table IV

| No. | Fuel | Lb. of dry fuel per therm delivered | Thermal efficiency per cent | Refuse per cent |
|---|---|---|---|---|
| | **Horizontal-Section Boiler** | | | |
| 1 | Gas coke.... | 11.19 | 68.0 | 5.7 |
| 2 | Dosco coke.... | 11.55 | 65.2 | 4.3 |
| 3 | Scotch anthracite.... | 10.82 | 66.0 | 5.1 |
| 4 | Welsh anthracite.... | 11.53 | 65.8 | 3.1 |
| 5 | Pennsylvania anthracite.... | 11.56 | 65.0 | 13.4 |
| 6 | Acadia run-of-mine.... | 13.10 | 59.1 | 14.6 |
| 7 | Springhill run-of-mine.... | 17.38 | 41.8 | 14.6 |
| 8 | English coke.... | 10.08 | 65.3 | 6.3 |
| 9 | La Salle coke.... | 13.10 | 75.8 | 7.1 |
| | **Vertical-section Boiler** | | | |
| 1 | Gas coke.... | 11.91 | 64.0 | 6.1 |
| 2 | Dosco coke.... | 12.38 | 61.5 | 6.4 |
| 3 | Scotch anthracite.... | 11.52 | 61.8 | 5.5 |
| 4 | Welsh anthracite.... | 11.30 | 61.5 | 2.1 |
| 5 | Pennsylvania anthracite.... | 13.17 | 56.5 | 13.8 |
| 6 | Acadia run-of-mine.... | 14.80 | 53.0 | 6.4 |
| 7 | Springhill run-of-mine.... | 18.30 | 39.6 | 5.4 |
| | **Drop-tube Boiler** | | | |
| 1 | Gas coke.... | 15.92 | 47.1 | 5.6 |
| 2 | Dosco coke.... | 11.27 | 66.4 | 4.1 |
| 5 | Pennsylvania anthracite.... | 11.84 | 64.4 | 14.4 |
| 7 | Springhill run-of-mine.... | 12.70 | 56.0 | 6.2 |

### Standard Boiler Trials

Boiler trials were run on all the 5-ton samples of coal which had been taken directly from the advanced working faces of the producing mines. The trials were conducted at the Nova Scotia Technical College according to the revised codes adopted for such tests by the American Society of Mechanical Engineers. The boiler used was of the horizontal return tubular type rated at 100 hp. and manufactured by I. Matheson and Company, Limited, New Glasgow, Nova Scotia. The method of hand firing was followed throughout. The boiler was equipped with Tupper grates and had means for forced draft by a Carling turbo-blower. The dimensions of the boiler were as follows:

Length—16 ft.
Diameter—60 in.
Heating surface—1,043 sq. ft.
Grate surface—22.90 sq. ft.
Volume of combustion space—800 cu. ft.
Distance from centre of grate to bottom of boiler—6 ft. 7 in.
Furnace volume per sq. ft. of boiler heating surface—0.144 cu. ft.

The setting had raised the boiler to a much greater height than was the customary practice. This was done for experimental purposes, because it was believed that a comparatively large space should be provided in the furnace so that the volatile gases distilled from the coal would be thoroughly mixed with air to promote complete combustion before being drawn through the tubes. It was found that the setting was too high for the greatest efficiency. After the standard trials were completed, the boiler was lowered and better heating results were secured. It was found that the distance from the grate to the boiler in plants using this type of boiler should vary according to the composition of the coal used.

The smoke connection from the boiler was 3 ft. in diameter and 50 ft. long with one right-angle bend. The Custodis brick stack was 3 ft. 6 in. in diameter at the top and 85 ft. high. The feed water was weighed from a large head tank, which served also as a feed water heater, and discharged into a hot well from which a Weir pump delivered the supply to the boiler. The temperature of the feed water was recorded continuously by a Tycos thermometer. The rate of steam flow was measured by a Bailey steam flowmeter. An artificial load for the boiler was provided by blowing the excess steam through a four-inch valve fitted with a Maxim silencer.

The combustion performance of the furnace was measured for carbon dioxide content in the flue gases by a Tag Mono recorder. A sampling tank was connected to the smoke uptake from which samples of flue gas could be obtained continuously. These were analyzed as a check on the recorder readings for carbon dioxide content and for percentages of carbon monoxide, oxygen, and nitrogen. Recording thermometers and draft gauges were also inserted at the other points where it was necessary to measure these factors.

The coal was weighed as fed to the boiler, and was fired by hand under the supervision and direction of the chief operator in charge of the trial. The first part of the run was made with the boiler kept at normal rating for ten hours and then the equipment was pushed up to a forced rating of approximately 150 per cent for as many hours as the remainder of the 5-ton sample would last. This latter period usually consisted of about six hours. The coal was sampled as it was fed into the boiler and the amount reserved was further crushed and divided to prepare the final sample for chemical analysis. The ash and clinker were weighed and sampled for a like purpose and were analyzed for the amount of remaining combustible matter as well as for calorific value.

The actual detailed data of the standard trials are too voluminous for a paper of this nature so that a statement of the comparative values of the different samples for steam-raising purposes as shown by these tests is all that is included. The results given cover both the runs at normal rating and in forced ratings. The fuel which gave the best performance is placed first and the others in succeeding order. The comparative efficiencies obtained are reported on a scale which is based on the assumption of 100 per cent for the coal which stood highest. The list is given for both normal and forced ratings, and appear in Tables V and VI.

Table V

Comparative Efficiencies at Normal Rating

| Sample No. | Relative efficiency per cent | Mine | Coal seam | Area |
|---|---|---|---|---|
| 4-23-15* | 100.0 | Allan | Foord | Pictou |
| 4-22-13 | 95.7 | McGregor | Fleming | Pictou |
| 4-23-16* | 94.8 | Allan | Foord | Pictou |
| 5-02-22 | 93.8 | No 2 | | Springhill |
| 4-24-16 | 93 4 | Albion | Third | Pictou |
| 4-24-17 | 93.4 | Albion | Cage-pit | Pictou |
| 1-16-01 | 93.0 | No. 16 | Lingan | Sydney |
| 1-04-04 | 89.7 | No. 4 | Phalen | Sydney |
| 5-07-21 | 89.7 | No. 7 | | Springhill |
| 1-02-03 | 88.3 | No. 2 | Phalen | Sydney |
| 4-22-12 | 88.0 | McGregor | McGregor | Pictou |
| 5-06-20 | 88.0 | No. 6 | | Springhill |
| 4-23-18* | 87.3 | Allan | Foord | Pictou |
| 4-23-17* | 86.3 | Allan | Foord | Pictou |
| 1-Pr-07 | 84.2 | Princess | Main | Sydney |
| 1-11-06 | 82.3 | No. 11 | Emery | Sydney |
| 1-Fl-08 | 82.2 | Florence | Main | Sydney |
| 5-06-20 | 81.5 | No. 6 | | Springhill |
| 1-1B-02 | 79.8 | No. 1B | Phalen | Sydney |

*For information regarding sample numbers see foot note * Table I.

### Weathering Characteristics of Nova Scotian Coals in Stock Piles

Since most of the coal mines of Nova Scotia are at or near tidewater, most of the product is transported to the consumers by boat. The St. Lawrence river is navigable as far as Montreal for large steamers, thus the bulk of exports to Quebec and Ontario are sent by this route. It is frozen over between the middle of November and the middle of April so that it is necessary to store large quantities of coal in stock piles both at the mines and in Upper Canada for comparatively long periods.

For many years there has been a persistent belief that the Nova Scotian coals deteriorated considerably when left out in the weather in a stock pile for several months. In

Table VI

Comparative Efficiencies at Forced Ratings

| Sample No. | Relative efficiency per cent | Mine | Coal seam | Area |
|---|---|---|---|---|
| 5-02-22 | 100.0 | No. 2 | | Springhill |
| 5-07-21 | 94.3 | No. 7 | | Springhill |
| 4-23-15 | 93.8 | Allan | Foord | Pictou |
| 4-22-13 | 92.6 | McGregor | Fleming | Pictou |
| 5-06-20 | 92.3 | No. 6 | | Springhill |
| 4-23-16 | 91.0 | Allan | Foord | Pictou |
| 1-11-06 | 90.5 | No. 11 | Emery | Sydney |
| 1-04-04 | 90.0 | No. 4 | Phalen | Sydney |
| 4-22-12 | 89.4 | McGregor | McGregor | Pictou |
| 4-24-16 | 89.4 | Albion | Third | Pictou |
| 1-02-03 | 88.7 | No. 2 | Phalen | Sydney |
| 1-16-01 | 87.1 | No. 16 | Lingan | Sydney |
| 1-1B-02 | 86.5 | No. 1B | Phalen | Sydney |
| 4-23-17 | 85.9 | Allan | Foord | Pictou |
| 4-23-18 | 85.2 | Allan | Foord | Pictou |
| 1-Fl-08 | 79.7 | Florence | Main | Sydney |
| 1-Pr-07 | 76.8 | Princess | Main | Sydney |
| 4-24-17 | 75.8 | Albion | Cage-pit | Pictou |

TABLE VII

WEATHERING TESTS OF SLACK COAL
Dominion No. 2 Mine, Sydney Area

CHEMICAL ANALYSIS

| Box No. | Original sample | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth buried (feet) | | | 7 | | 5 | | 7 | | 5 | | 2 | | 3 | |
| Time buried (days) | | | 79 | | 77 | | 156 | | 156 | | 154 | | 160 | |
| Moisture condition | R | D | R | D | R | D | R | D | R | D | R | D | R | D |
| Proximate analysis | | | | | | | | | | | | | | |
| Moisture ... per cent | 1.8 | | 2.7 | | 2.9 | | 1.6 | | 1.5 | | 1.2 | | 1.7 | |
| Volatile matter ... per cent | 32.6 | 33.2 | 33.9 | 34.9 | 34.3 | 35.2 | 31.7 | 32.3 | 31.9 | 32.4 | 32.4 | 32.8 | 31.4 | 31.9 |
| Fixed carbon ... per cent | 57.6 | 58.6 | 55.1 | 56.7 | 55.0 | 56.5 | 57.7 | 58.6 | 58.9 | 59.8 | 58.7 | 59.4 | 59.2 | 60.3 |
| Ash ... per cent | 8.0 | 8.2 | 8.1 | 8.4 | 8.0 | 8.3 | 9.0 | 9.1 | 7.7 | 7.8 | 7.7 | 7.8 | 7.7 | 7.8 |
| Ultimate analysis | | | | | | | | | | | | | | |
| Carbon ... per cent | 76.6 | 78.0 | 76.3 | 78.5 | 75.4 | 77.6 | 75.4 | 76.6 | 77.7 | 78.9 | 77.2 | 78.2 | 77.1 | 78.4 |
| Hydrogen ... per cent | 5.1 | 5.0 | 5.0 | 4.8 | 5.0 | 4.8 | 5.1 | 5.0 | 5.2 | 5.1 | 5.2 | 5.1 | 5.3 | 5.2 |
| Ash ... per cent | 8.0 | 8.2 | 8.0 | 8.3 | 8.1 | 8.4 | 9.0 | 9.1 | 7.7 | 7.8 | 7.7 | 7.8 | 7.7 | 7.8 |
| Sulphur ... per cent | 2.2 | 2.3 | 2.1 | 2.1 | 2.3 | 2.4 | 2.1 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 1.9 | 1.9 |
| Nitrogen ... per cent | 1.9 | 1.9 | 1.6 | 1.6 | 1.5 | 1.5 | 1.6 | 1.6 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.6 |
| Oxygen ... per cent | 6.2 | 4.6 | 7.0 | 4.7 | 7.7 | 5.3 | 6.8 | 5.5 | 5.7 | 4.5 | 6.2 | 5.2 | 6.5 | 5.1 |
| Calorific value | | | | | | | | | | | | | | |
| B.t.u. | 13,700 | 13,950 | 13,720 | 14,110 | 13,590 | 13,990 | 13,340 | 13,550 | 13,770 | 13,980 | 13,840 | 14,000 | 13,850 | 14,000 |

NOTE:—R—as received; D—dry basis.

the mine itself there is a constant exudation of gas from the working faces of the coal seam underground. In a mine a good deal of this is caused by the great pressures existing in such places and action of this kind does not continue to any considerable extent after the coal is broken up and raised to the surface. There is direct oxidation of very fine coal when it comes in contact with the air and the pyrite in coal weathers fairly rapidly when it comes under the influence of moisture and oxygen as it does in stock piles. These chemical reactions may cause heating and spontaneous combustion in piles of coal in small sizes especially with slack. Different coals have widely varying characteristics regarding their liability to spontaneous combustion and stock piles must be watched and occasionally tested for local heating.

Part of the investigation was devoted to tests under practical weathering conditions to find out how much change in composition took place in the stock piles at the mines and elsewhere. The tests were limited to a few samples of slack. A skeleton box frame, 2 ft. by 1½ ft., was made by welding ¾ by ¾ in. angle iron together at the corners. This was covered first with copper wire screening which had 16 meshes per inch and then with strong galvanized iron wire with 2 meshes per inch to protect the contents when roughly handled. The boxes were filled with freshly mined slack and buried at varying depths in the regular bank of slack that was built up during the winter at the mine. When the coal was lifted by the steam shovel during the next spring the box was recovered and a chemical analysis of it was made. These boxes were exposed to the regular influences of frost, snow, rain and air which acted on the bank as a whole for periods varying from two and a half to five months.

The results are set forth in Tables VII and VIII.

If the analyses of the samples of the different boxes are averaged and compared with that of the original sample in both tests, the results shown in Table IX are obtained.

TABLE VIII

WEATHERING TESTS OF SLACK COAL
Princess Mine, Sydney Area

CHEMICAL ANALYSIS

| Box No. | Original sample | | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth buried (feet) | | | 3 | | 6 | | 6 | | 3 | |
| Time buried (days) | | | 126 | | 126 | | 126 | | 126 | |
| Moisture condition | R | D | R | D | R | D | R | D | R | D |
| Proximate analysis | | | | | | | | | | |
| Moisture ... per cent | 1.9 | | 2.0 | | 1.5 | | 1.6 | | 1.7 | |
| Volatile matter ... per cent | 37.0 | 37.7 | 36.8 | 37.5 | 36.4 | 37.0 | 36.9 | 37.5 | 37.0 | 35.6 |
| Fixed carbon ... per cent | 50.2 | 51.2 | 51.7 | 52.8 | 50.5 | 51.3 | 50.5 | 51.3 | 51.1 | 52.0 |
| Ash ... per cent | 10.9 | 11.1 | 9.5 | 9.7 | 11.6 | 11.7 | 11.0 | 11.2 | 10.2 | 10.4 |
| Ultimate analysis | | | | | | | | | | |
| Carbon ... per cent | 71.9 | 73.3 | 73.4 | 74.9 | 72.6 | 73.7 | 72.5 | 73.6 | 72.3 | 73.5 |
| Hydrogen ... per cent | 5.3 | 5.2 | 5.1 | 5.0 | 5.1 | 5.0 | 5.2 | 5.1 | 5.2 | 5.2 |
| Ash ... per cent | 10.9 | 11.1 | 9.5 | 9.7 | 11.6 | 11.7 | 11.0 | 11.2 | 10.2 | 10.4 |
| Sulphur ... per cent | 2.4 | 2.4 | 2.3 | 2.4 | 2.1 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Nitrogen ... per cent | 1.7 | 1.8 | 2.0 | 2.0 | 1.3 | 1.3 | 1.2 | 1.3 | 1.8 | 1.8 |
| Oxygen ... per cent | 7.8 | 6.2 | 7.7 | 6.0 | 7.3 | 6.1 | 7.9 | 6.6 | 8.3 | 6.9 |
| Calorific value | | | | | | | | | | |
| B.t.u. | 12,900 | 13,150 | 13,290 | 13,570 | 12,890 | 13,080 | 13,030 | 13,230 | 13,120 | 13,350 |

NOTE:—R—as received; D—dry basis.

Table IX

| | Analysis original sample | Average analysis weathered sample |
|---|---|---|
| Dominion No. 2 Mine | | |
| Moisture....................per cent | 1.8 | 1.9 |
| Volatile matter................per cent | 32.6 | 32.6 |
| Fixed carbon..................per cent | 57.6 | 57.5 |
| Ash.........................per cent | 8.0 | 8.0 |
| Sulphur.....................per cent | 2.25 | 2.12 |
| Calorific power...........B.t.u. per lb. | 13,700 | 13,680 |
| Princess Colliery | | |
| Moisture....................per cent | 1.9 | 1.7 |
| Volatile matter................per cent | 37.0 | 36.8 |
| Fixed carbon..................per cent | 50.2 | 50.9 |
| Ash.........................per cent | 10.9 | 10.6 |
| Sulphur.....................per cent | 2.4 | 2.2 |
| Calorific power...........B.t.u. per lb. | 12,900 | 13,080 |

A test of longer duration was run on a sample of Acadia coal from the Pictou area. A sample of freshly mined run-of-mine coal was taken from a carload shipped to Halifax and four boxes were buried in the stock pile at the Round House of the Canadian National Railways on the outskirts of the city. They remained there out of doors under the influences of the weather for two years and two months before they were lifted, sampled and analyzed. (See Table X.)

The indications are clear that the chemical composition of these Nova Scotian coals is altered to only a slight degree by exposure to the weather for those periods for which it is ordinarily necessary to bank it at the mine or in the yard of the consumer. The weathering improved the quality of the fuel somewhat, because some of the pyrite was oxidized to reduce the sulphur content and the calorific power is slightly increased because of the greater percentage of fixed carbon.

Summary

The purpose of the investigation was to secure scientific data on the characteristics and qualities of the coals that are being mined and distributed from Nova Scotia at the present time. These should be of definite value to the consumers in the province, but especially to those in Ontario and Quebec where there is a large variety of fuels available for power and heating purposes.

Table X

| | Analysis original sample | Average analysis weathered sample |
|---|---|---|
| Moisture......................per cent | 3.0 | 2.7 |
| Volatile matter..................per cent | 29.8 | 28.1 |
| Fixed carbon....................per cent | 53.9 | 56.0 |
| Ash...........................per cent | 13.3 | 13.4 |
| Sulphur.......................per cent | 1.25 | 1.09 |
| Calorific power.............B.t.u. per lb. | 12,170 | 12,230 |

Chemical analyses were made of both channel and large scale samples taken from the advanced working faces in all the important producing mines and these results may be taken as indicative of the composition of shipments at the present time. The proximate analysis, ultimate analysis, calorific power, and the temperature of fusion of the ash of each coal that is shipped to central Canada in any considerable quantity have been made available for reference.

Trials were run on a number of fuels which are commonly used in domestic hot-water boilers for house-heating and the results show that coke prepared from Nova Scotian coal will give satisfaction and efficiency equal to the results secured from imported anthracites. If cost is an important factor with the householder he can save money by using the fuel that is produced from the local soft coals.

Standard boiler trials were run on all the coals in an ordinary horizontal return-tubular boiler fired by hand and run at both normal and forced rating. The results are given in a sequence of comparative efficiencies, but this order might be considerably altered in other types of boilers run under other conditions. The cost of the fuel is an all-important factor in steam generation and this varies widely according to the geographical position of the place where the coal is consumed.

Tests were made on the effects of weather on Nova Scotian coals that must be banked for a few months while the St. Lawrence river is frozen up. These show that the coal under these conditions does not deteriorate in its composition to any great extent and the small change that does take place is in the direction of improving the quality.

The data are presented for the use of the combustion engineer or the industrial manager in making plans for new steam-power plants, additions or changes to present plants, or for the adaptation of special mechanical boiler-room apparatus in that part of Canada where Nova Scotian fuels are available. This is a time when many changes and additions to steam generating plants are being planned and contemplated and it is important from a provincial and national standpoint that Nova Scotian fuels should have the most thorough consideration wherever they might be used. Technical and scientific data of all kinds are accessible regarding all the American coals which are brought into Ontario in such large quantities. The results of the tests on those produced from the deposits on the Canadian Atlantic seaboard should serve as reliable basis of study for purchasing agents, engineers, and other consumers who are in a position to secure bituminous coal mined in Nova Scotia.

# An Economic Use for New Brunswick Coal

## The Grand Lake Plant, New Brunswick Electric Power Commission

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

**SUMMARY.—Deals with the successful use of a local slack coal, high in ash and moisture, in pulverized form in a modern steam plant of 12,500 kw. capacity. Five years' experience with furnace walls, air preheating, superheat, fans, mills and burners is described; tables of costs and operating results are given.**

The following facts and conclusions about efficiency and economy in the use of New Brunswick coal from the Minto field, are based on the design and performance of the steam plant of the New Brunswick Electric Power Commission at Grand Lake.

The Grand Lake, or as it is now called, the Minto Coal field, contains the oldest workings in America. Situated in the D'Amour Seigneury, and close to old Acadian settlements on navigable water, the deposit was discovered in 1620 and a shipment of coal was made to the Colony of Massachusetts Bay in 1628. In his diary, in 1665, Samuel Pepys expressed regret that France had been left in possession of the debatable ground of the St. John Valley as the "only coal in the North American Colonies is on the Great River of Acadia."

Notwithstanding its early development, the use of Minto coal extended slowly. The discovery of the great deposits of Nova Scotia and Pennsylvania and the natural provision by manufacturers of combustion equipment for these lower volatile and more uniform coals account for the neglect of the New Brunswick field. But since the completion of a railway to the mines about twenty-five years ago, the coal has found a much more extended use for railway and industrial purposes.

The plant of the New Brunswick Electric Power Commission at Grand Lake, however, affords the only example of the exclusive use of the lowest grades of slack coal from this area, on a comparatively large scale, and under modern conditions of rating and efficiency. It is hoped that the methods used and the results obtained may be of some interest, especially as concerning the only coal mined in Canada between Nova Scotia and Saskatchewan.

In 1928 it became evident to the New Brunswick Electric Power Commission that its hydraulic plant at Musquash would soon prove unable to supply the expanding needs of its customers and the future demands of industry. Consequently an estimate of the energy requirements up to 1937 was made and this has, luckily, proved to be substantially correct.

An investigation of the available hydraulic sites resulted in the conclusion that none was economically sound or even physically adequate. Thus the construction of a fuel plant became a necessary part of the Commission's programme and its engineers and consultant had to arrive at decisions on the following points:—

1. Fuel to be used and its cost per kw.h. at the load factors expected.
2. Location of plant with respect to fuel, water and point of delivery of energy.
3. Steam conditions justified by fuel cost and load factor.
4. Capital, sinking fund and maintenance costs implied by previous decisions.
5. Terms on which new contracts could be made, notably for the supply of Fredericton and of the factory of the Canadian Cotton Company at Marysville.

This list of interdependent factors had to be dealt with definitely, as the work could not be justified without the completion of long term contracts for the Fredericton district. That the estimates made at this time proved substantially correct is due rather to good fortune than to the possession of the gift of prophecy which every good engineer should have.

The accompanying map (Fig. 1) shows the districts served by the Commission and the location of the Grand Lake plant.

After a preliminary investigation lasting for over a year, it was decided to advise the Commission to construct a plant on the shore of Grand Lake, in the centre of the mining area and designed to burn the local slack coal in any of its various grades.

The advice then given that a plant could be built, with reasonable capital and maintenance charges, to generate a kw.h. with 2 pounds of wet slack, involved a decision which would inevitably determine the future usefulness of the Commission's work.

Methods of purchasing and continuous sampling and testing, as will appear, had to be devised at this stage. In fact, the major part of the engineering for the combustion side of the undertaking was done in this preliminary study.

The information kindly given by the engineers of the Nashwaak Pulp and Paper Company at this time was of vital importance. This company, from 1928 to 1930 used Minto coal in pulverized form at its mill at Fairville, N.B. It then suspended operation, at this location, but not for reasons of suitability or economy of fuel. The Combustion Engineering Corporation, of Montreal, who made the Nashwaak equipment, also supplied information of the greatest use.

The pioneer work done by and for these companies provided the Commission with data which otherwise could hardly have been acquired in time for its undertaking.

After the completion of these preliminary studies, and when the Commission had made the necessary financial arrangements, the initial development was proceeded with.

This first installation, completed in 1931, contains two 2,500-kw. Oerlikon generating units. These do not come within the scope of this paper and will not be referred to again, but it is fair to state that their efficiency and remarkable durability played an essential part in the economic success of the original scheme.

The addition, in 1936, of a 6,250-kw. Parsons turbine with a Combustion Engineering steam generating unit with Kidwell boiler, was made by the Commission's engineers and consultant. The building, piping, auxiliary lay-out and electrical work were the particular work of the Commission, while to the contractors for the turbine and steam generating unit belongs, rightly, the responsibility for design in their respective fields. They both fully met their performance guarantees.

Table I

Steam Generating Units

Steam condition—440 lb. per sq. in.—650 deg. F.
Vacuum 28.5 in. in summer
Vacuum 29 in. in winter
1931—Two 600-h.p. Kidwell boilers, each with two Foster-Wheeler mills and burners.
Combustion Engineering water walls and preheaters.
Capacity of each 62,000 lb. per hr.

1936—One 800-h.p. Kidwell boiler with three mills, boilers and water walls and preheaters.
Capacity 100,000 lb. per hr.

The actual peak capacity has now been found to be 12,500 kw. Boiler ratings of 325 per cent are maintained with slack coal containing 22 per cent ash and 8 per cent water.

### The Minto Coal Deposit

The Minto coal deposit, which is of unknown extent, occurs and is worked at depths from outcrop to 180 ft., the latter being about 40 ft. below sea level.

The seams are thin, averaging perhaps 20 in. A 5-in. seam is also present but is not worked. "Sulphur balls" which are extremely hard and cannot be crushed or pulverized are sometimes present. Slack coal, which generally means passage through a 5/8-in. screen, will absorb and hold up to 10 per cent water. Careful mining is required to prevent the accidental inclusion of bone which is contiguous to the coal but which will not burn. The ash fusion temperature is as low as 1,700 deg. F. in some instances.

Analyses similar to the following were available in great numbers and similar variety during the preliminary studies. It was also known, from experience in various industrial and heating plants, that the source of origin did not determine quality and that the percentages of water given by the authority quoted were inherent moisture and bore no relation to the water or ice, in slack from a wet working, shipped in an open car. It was known that slack could hold and retain up to 10 per cent water.

Table II
Typical Proximate Analyses*

| Origin | Per cent | | | | | B.t.u. per lb. | |
|---|---|---|---|---|---|---|---|
| | Water | Volatile | Carbon | Ash | Sulphur | (a) | (b) |
| A | 2.0 | 29.0 | 50.6 | 19.5 | 6.5 | 11,800 | ..... |
| B | 1.1 | 30.1 | 51.0 | 18.9 | ... | 12,000 | ..... |
| C | 1.3 | 30.5 | 51.4 | 18.1 | 11.3 | 12,100 | 11,830 |
| D | 1.1 | 32.3 | 54.0 | 13.7 | 6.3 | 12,800 | 13,030 |
| E | 0.7 | 29.8 | 48.8 | 23.4 | ... | 11,400 | ..... |
| F | 1.4 | 33.8 | 60.4 | 5.8 | 2.0 | 13,900 | 14,170 |

*All data are from the Department of Mines except B.t.u. (a) which are calculated.

Since, however, it was necessary to describe the coal to contractors who wished to submit proposals and yet not encourage design solely for extreme conditions, the following typical proximate analysis was given in the Commission's specification:—

| Water | Volatile | Carbon | Ash | B.t.u. approx. |
|---|---|---|---|---|
| 4 per cent | 32 | 48 | 16 | 12,000 |

Sulphur (separate determination) may be from 6 to 10 per cent, and the equipment must work (at less efficiency

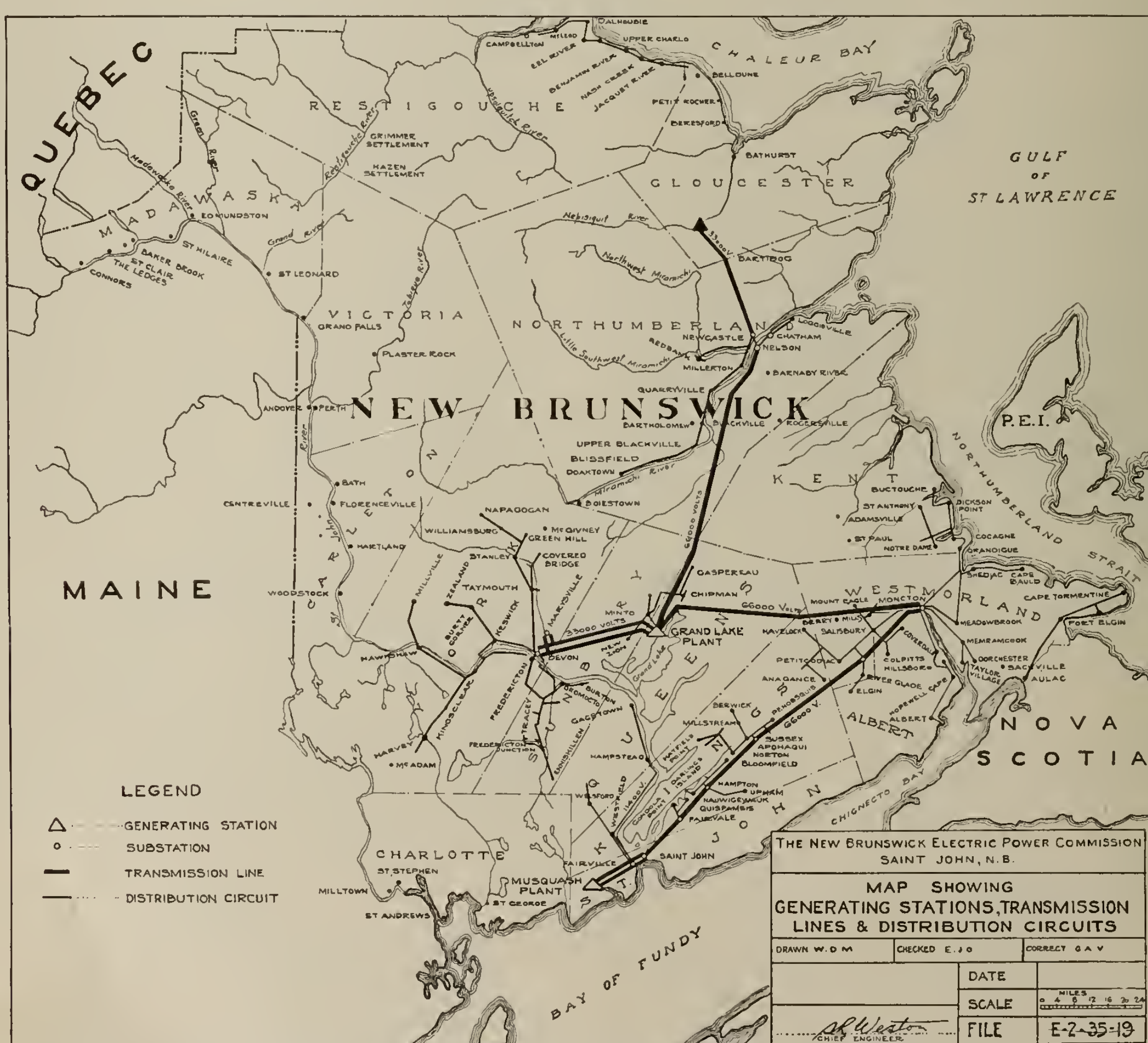


Fig. 1—District Served by New Brunswick Electric Power Commission.

of course) with a maximum of 8 per cent water and 24 per cent ash.

From the above, it may be understood that the problem is in no way similar to that of purchasing and using non-absorbent dry coal from a thick uniform seam. In fact it is hard to make engineers realize that a coal will absorb so much moisture.

One prospective contractor offered to design equipment if sent "a 30 pound sample of coal," another expressed the

**Fig. 2—Grand Lake Power Plant.**

opinion that "all Maritime coals are very much alike." These examples serve to show that there is need for knowledge of eastern coals among Canadian manufacturers.

### Sampling and Testing Coal

In buying this coal the most important measurement is the determination of water. Should 1,000 lb. of coal be taken as a sample and quartered in the usual way, the absorbed moisture is largely lost. Therefore it has been necessary to develop a method of sampling and testing which could be applied readily and cheaply, and which would meet the peculiar local conditions.

For sampling, twelve pieces of two inch pipe, each two feet long, are driven into the coal, six on each side of the car. The cores thus obtained are mixed as quickly as possible, and a sample weighing about 5 lb. is placed on a shallow tray and oven dried.

Frozen slack with 7 to 10 per cent ice still presents an unsolved problem.

Ash is determined in the usual way from a small ground sample. The Commission only pays for combustible.

The B.t.u. value is not determined at the plant. Experience of many years indicates that this determination requires the services of a very skilful and devoted laboratory worker. The four or five significant figures in which results of energy content are so often given indicate a general ignorance of the actual precision of this test.

As Minto coal, unless very high or very low in sulphur, contains approximately 15,000 B.t.u. per lb. of combustible, calorimeter tests seem superfluous except as an occasional check on the general character of the combustible.

The Commission was advised, in 1931, to buy on a percentage of combustible basis. The base price is paid for coal of 16 per cent ash, the average value for the area. A bonus is given for less and a penalty is exacted for more ash. The specification, which has been used successfully for the past six years, is omitted for the sake of brevity, but it is available to anyone who is interested.

### Quality of Coal Used at Grand Lake

The quality of coal actually in use can now be given from the experience of six years. For the year June 1st, 1932 to May 31st, 1933, the results are as follows, six independent mine operators supplying various quantities of coal.

Table III

| Operator | Tons | Average per cent combustible | Average per cent combustible for all operators | Deduction for quality under contract | Average cost per ton combustible including freight |
|---|---|---|---|---|---|
| A. | 6,568 | 80.87 | 82.2 | 8.6c. per ton | $4.03 |
| B. | 3,050 | 84.4 | | | or |
| C. | 3,426 | 81.5 | | | 74,000 |
| D. | 522 | 85.5 | | | B.t.u. |
| E. | 1,217 | 83.1 | | | for |
| F. | 1,048 | 82.2 | | | 1 cent |

During this year run of mine coal was used when slack was not available. The results naturally show the influence of a less absorbent form of coal. Also, the cost is somewhat higher than for all slack.

During the year ending October 31st, 1936, corresponding results from thirteen independent mine operators were:

Table IV

| Tons | Average per cent combustible for all operators | Deduction for quality under contract | Average cost per ton combustible including freight |
|---|---|---|---|
| 24,310 | 79.4<br>Max. 92.4 per cent (51 tons)<br>Min. 76.4 per cent (8,550 tons) | 20.05c. per ton | $3.64 or 82,000 B.t.u. for 1 cent |

This year, screening was practised on a larger scale and slack was available from more operators. Thus, the plant is fulfilling one of the reasons for its inception and is enabling the coal operators to sell slack for use in power production and dispose of screened sizes at a much higher price than formerly obtained for run of mine.

The quality of the coal actually burned has proved substantially the same as had been anticipated, thus there is no excuse for faulty design of combustion equipment. The mistakes made in the first installation were minor but will be indicated.

### Essential Factors in Design of Grand Lake Plant*

1. *Extent and Character of Furnace Water Wall Surface*

Experience at the Nashwaak plant indicated positively that slagging of the fusible ash occurred on all refractory surfaces near the flame, and notably on the front wall which was not water cooled. Thus it was determined to cool all four walls at the Grand Lake plant. A certain weight of opinion was advanced to the effect that this would cause extinction of the flame and danger of serious puffs. This idea has proved to be unfounded.

The fin tube type of water wall was adopted, and, whatever may be the merits of other walls, in this case it has proved successful. Where there are fin tubes there is no slagging. In the first installation, there is some exposed refractory on the front wall near the burners. This has slagged and required maintenance.

After five years experience, it was decided to cool the front wall as completely as possible. This has prevented slagging and the new unit may be left on the line indefinitely as far as combustion conditions are concerned. There has been no maintenance of fin walls.

*See Fig. 3.

The original value for energy release in relation to cooled furnace wall surface is 35,000 B.t.u. per hr. per sq. ft. This proved successful, and is the same in the new unit. The distribution of the surface, however, has been changed in the front wall design.

2. *Energy Release and Furnace Volume*

A low value for energy release (16,000 B.t.u. per cu. ft. per hr.) was used as a basis of design. This has proved satisfactory and has been adhered to in the new boiler. Indeed it is believed that no furnace or boiler has been operated yet to its limit, although all have produced more steam than promised in the contracts.

The effect of this low energy release on superheater design will be referred to. Otherwise, the large furnace volumes are only objectionable as they affect capital cost.

3. *Air Preheating*

Again, from the Nashwaak experience, as well as from obvious theoretical reasons, the need of ample air preheater capacity was recognized. The first installation has 3,960 sq. ft. surface for each unit, or 64 sq. ft. per 1,000 lb. of steam per hr. This has worked well. There is no visible depreciation in five years. The corrugated plate surfaces remain clean and an air temperature of about 340 deg. F. is maintained at all loads.

But, from extreme conditions of wet coal, it was decided to try to get a higher air temperature in the new plant. Consequently, the new preheater has a surface of 10,900 sq. ft. or about 110 sq. ft. per 1,000 lb. of steam. An air temperature of about 420 to 450 deg. F. is maintained and it is believed that this increase has been justified by results. It represents a maximum however, as no risk must be run of approaching the dew point in the steel stack. The formation of sulphuric acid from the high sulphur content of the fuel would cause destructive corrosion. For this reason, also, the omission of an economizer may be necessary.

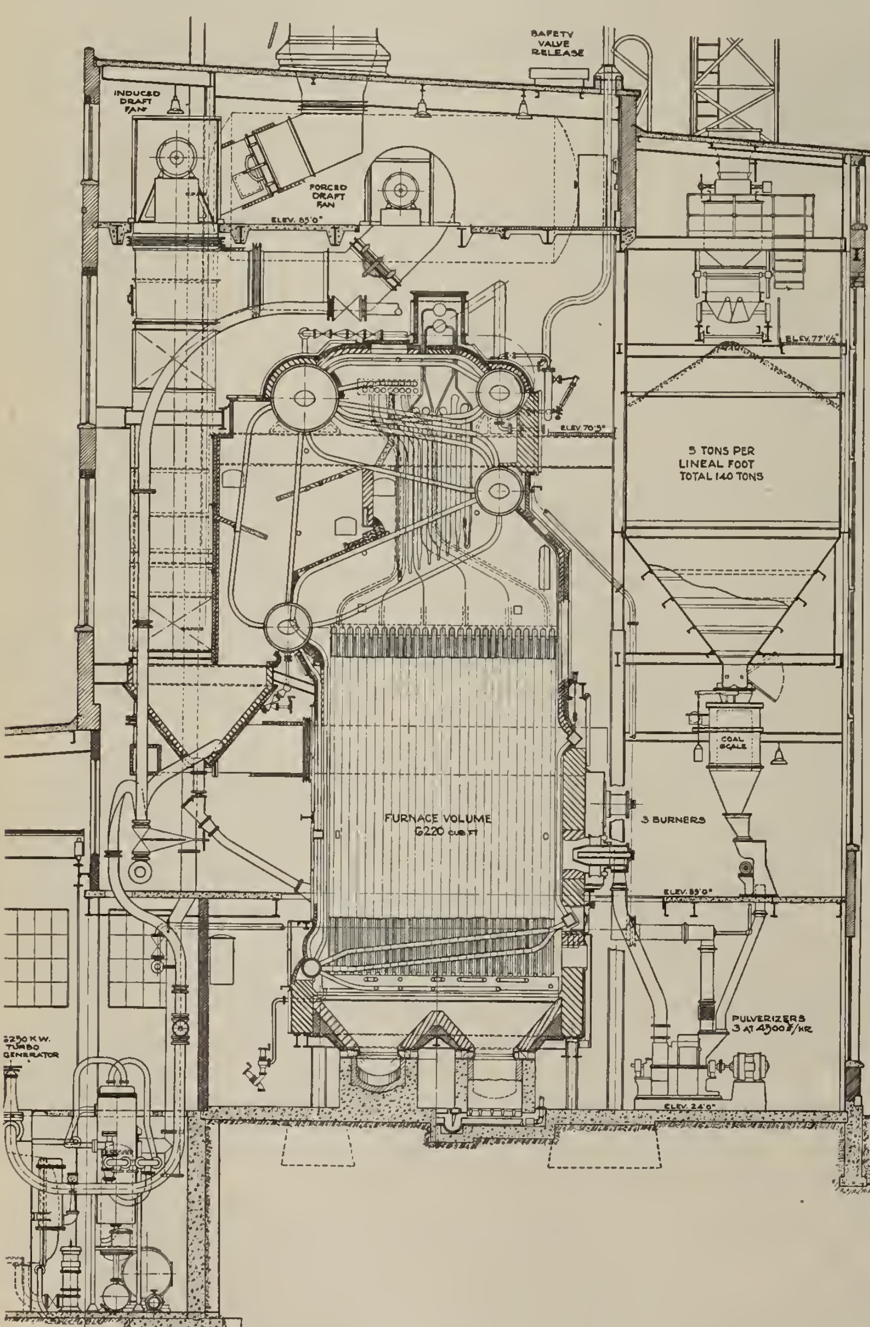


Fig. 3—Cross Section Showing General Arrangement, No. 3 Boiler.

4. *Superheat*

The large furnace volume in the original boilers and the consequent low temperatures in the first tube bank produced the superheat condition illustrated in the accompanying performance chart (see Fig. 4). This condition was afterwards improved somewhat, but persists still in kind, if not in degree.

Therefore it was determined to have enough surface to ensure 200 deg. superheat. The new unit, although the largest which could be used, has failed to realize expectations. While it is satisfactory, its performance shows that high temperatures cannot be obtained by this type of superheater with a Kidwell boiler. It appears that the superheater at about 650 deg. F. radiates back to the first bank tubes at about 450 deg. F. This is pointed out as a warning to other users of large furnace volumes.

No solution of the problem is offered here as, if one were known it would have been applied at Grand Lake. It was claimed that fin wall slagging would improve superheat. Slagging has not occurred.

5. *Fans*

Owing to the large percentage of fly ash, rapid erosion of the induced draft fans was expected. This has not occurred. Rotors last nearly two years and are then successfully repaired by building up with electric welding.

In the first installation, constant speed fan drive was adopted. This was a mistake. Auxiliary power was excessive and damper erosion occurred very rapidly. The old fan units have now been fitted with variable speed hydraulic couplings and these were included in the new specifications. This method has given much better draft control and a marked economy in auxiliary power.

It is believed however that all fans are too large, even for extreme conditions, with what once was erroneously believed to be a difficult coal.

6. *Mills and Burners*

Impact mills were advised on account of the wet coal condition. The first boilers had each two mills and burners made by the Foster Wheeler Company of Montreal. These have worked satisfactorily to date. The power requirement is in excess of that of the new mills, but the grinding appears to be finer. Plugging with wet coal occurs with a lower percentage of moisture than with the new mills. This, no doubt, is influenced by the smaller preheaters. The original burners required modification during preliminary operation and water cooling had to be employed. One water jacket has been repaired in six years operation.

The new mills and burners, of which there are three, were made by the Combustion Engineering Corporation, of Montreal. Operation was successful from the first run, power requirements have been reduced and water cooling is not employed.

Mill maintenance is easy, but, where loads are not under the control of the management, the frequent necessity of taking a mill off to change hammers creates some anxiety. So far, however, these changes have been made without difficulty.

It is believed that the use of three burners and the increased space for flame travel are good features in the new unit. The mills have handled coal up to 9.6 per cent moisture in an emergency and the boiler has operated at loads of from 10 to 110 per cent of its contract capacity.

In connection with the subject of mills and burners, it may be of interest to note that no interruption of service has occurred in connection with fuel preparation and combustion, since 1931, except in one instance when wet coal plugged a spout.

Table V-Typical Results of Mill Operation

| | 9.30 to 11.30 Oct. 26 | 2.30 to 3.30 Oct. 27 | 10.00 to 11.00 Oct. 27 | 9.00 to 10.00 Oct. 28 |
|---|---|---|---|---|
| **Mill 3A** | | | | |
| Feed | 7.39 | 5.56 | 5.17 | 5.20 |
| Amperes | 45. | 38.5 | 29.2 | 30. |
| Coal......lb. per hr. | 8,400 | 3,800 | 3,400 | 3,400 |
| Pri. air | 5.9 | 5.76 | 6.56 | 6.4 |
| Sec. air | 1.9 | 2.4 | 1.96 | 1.5 |
| Temp. to mill | 220 | 274 | 180 | 201 |
| Temp. from mill | 140 | 161 | 149 | 140 |
| **Mill 3B** | | | | |
| Feed | | 6.52 | 4.70 | 5.25 |
| Amperes | | 56. | 42.6 | 44. |
| Coal......lb. per hr. | | 3,800 | 2,800 | 3,200 |
| Pri. air | | 5.62 | 7.0 | 6.12 |
| Sec. air | | 1.84 | 2.0 | 1.5 |
| Temp. to mill | | 169 | 160 | 162 |
| Temp. from mill | | 147 | 143 | 146 |
| **Mill 3C** | | | | |
| Feed | 6.72 | 6.20 | 5.98 | 5.2 |
| Amperes | 44. | 43.5 | 43.5 | 38. |
| Coal......lb. per hr. | 8,000 | 3,800 | 4,700 | 4,000 |
| Pri. air | 5.92 | 5.6 | 6.84 | 6.76 |
| Sec. air | 1.7 | 1.76 | 1.96 | .8 |
| Temp. to mill | 209 | 224 | 208 | 175 |
| Temp. from mill | 139 | 145 | 142 | 146 |
| Steam flow...lb. per hr. | 64,000 | 90,000 | 93,000 | 93,000 |

Coal samples were taken from mills 3B and 3C at 10.00 a.m. on October 27th in order to get a comparison of the grinding obtained when using twelve hammers and sixteen hammers. At this time mill 3B had been running approximately thirty-four hours and mill 5C approximately forty hours. The following results were obtained:—

Table VI

| | Mill 3B | Mill 3C |
|---|---|---|
| Through 48 mesh | 98.4 per cent | 94.3 per cent |
| Through 100 mesh | 94.0 per cent | 83.9 per cent |
| Through 200 mesh | 88.2 per cent | 73.3 per cent |

The above results are not necessarily examples of good operation. The runs were made to determine doubtful points about operation and to determine mill power and performance.

7. *Explosion Doors*

Only one puff, so far, has occurred which could be the cause of any alarm. It was caused by a mistake made during preliminary operation in 1931. No damage was done.

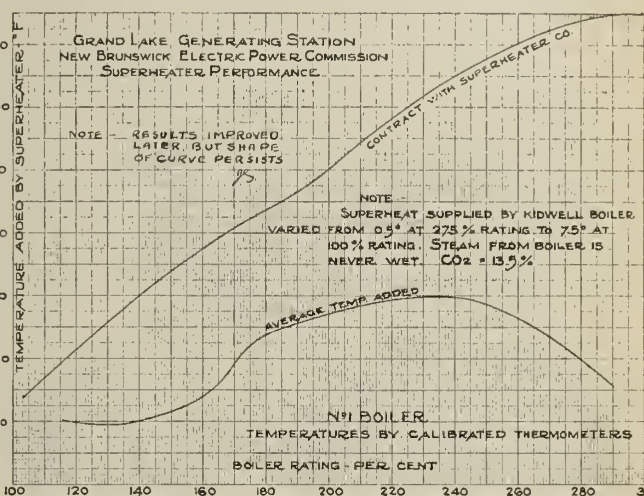


**Fig. 4—Superheater Performance, Grand Lake Generating Station.**

Nevertheless, in the new unit, a change was made from the conventional door to simple pot lids. These are believed to exclude air better. The complete steel casing is also a change which has improved operation.

8. *Ash removal*

The staggered water screen at 14-inch centres in the initial plant has been embodied in the new. Ash removal presents no difficulty and no manual work is required.

9. *Soot blowing*

The large percentage of fly ash keeps the surfaces clean. Blowing is done with a pressure of 100 lb. per sq. in. Very little blowing is effective. Although abrasion keeps the surfaces clean it is not apparent that erosion occurs.

Plant Performance

The tabulations of performance and cost which appear in the Appendices are based on routine operation over long periods. Coal is weighed by scales which are correct to at least three figures.

Steam flow is measured by Bailey meters but, with the new unit, the flow values have been checked by a 2-in. orifice, calibrated by direct weighing, on the condensate. Flow values are correct to two and one half significant figures.

No numerical reference is made to the somewhat cryptic term "boiler efficiency." The author does not understand it, and, even were this not so, operation with variable coal, mixed in a bunker, would make values misleading on any basis.

Capital overheads are computed on the cost of the whole plant and will diminish. The first installation required the purchase of land, the construction of a railroad, the provision of circulating water canals and many items of permanent value. The new installation cost $74 per kw. of peak capacity. This includes building, coal handling and every physical item, ready to run. It also includes organization, preliminary operation, engineering and every indirect overhead which can be found.

Of the cost of the new unit, the steam generator, complete with mills and burners and all auxiliaries connected with combustion cost $20 per kw. Material and supervision were supplied by the contractor, labour by the Commission.

Interest, sinking fund and maintenance is allowed for at a total of 9 per cent. This leaves provision for a maintenance reserve well over actual costs so far. The other cost items, are it is hoped, self explanatory.

The Commission designed and constructed everything except items directly a part of the boiler and turbine contracts.

### Conclusion

Fuel preparation costs about 23c with the old and 21c with the new equipment. Auxiliary power has been reduced from about 9 to about 5.5 per cent.

It will be noted, in the cumulative tabulation for 1935, before the operation of the new plant, that with 39.1 per cent load factor, 2 lb. of coal were used per kw.h. This is a fortunate agreement with the estimate of 1930.

A comparative value of 1.53 lb. was attained in October 1936. This improvement is rather due to better load factor, lower auxiliary power and better heater and evaporator layout than to any want of specific efficiency in the old main units. Although it is hoped that this paper is free from matter not pertinent to the use of a particular coal, it should be stated that the new 6,250-kw. unit with its condenser, heaters and evaporator contributes materially to the result and has shown economy better than contract figures.

After six years experience, it has been found that the use of New Brunswick coal, in a centrally located plant, is justified.

From no other source can energy in the form of prepared coal be obtained so cheaply within reach of the Commission's customers. It is felt that there may be other power users, so geographically placed that this may be of interest.

In the preparation of the above, the writer is indebted to S. R. Weston, M.E.I.C., chief engineer of the New Brunswick Electric Power Commission, and his staff.

### Appendix I

Grand Lake Generating Station

Operating summary for the month of October, 1936

| | October 1936 | October 1935 | Cumulative 1936 | Cumulative 1935 |
|---|---|---|---|---|
| Power generated........kw.h. | 4,277,700 | 3,283,700 | 27,226,200 | 20,204,100 |
| Power, output to lines......kw.h. | 4,027,140 | 3,040,880 | 24,842,960 | 18,427,140 |
| Power station service.......kw.h. | 250,560 | 242,820 | 2,383,240 | 1,777,060 |
| Maximum load..............kw. | 8,800 | 5,900 | 8,800 | 5,900 |
| Load factor..................% | 65.5 | 75.0 | 35.4 | 39.1 |
| Steam generated (1,000 lb.)...... | 56,133 | 50,478 | 402,596 | 346.952 |
| Steam to turbines (1,000 lb.)..... | 55.153 | 44,416 | 369,328 | 284,239 |
| Steam (% of gen.) sta. service..% | 1.75 | 12 | 8.3 | 18.05 |
| Elec. (% of gen.) sta. service...% | 5.9 | 7.38 | 8.8 | 8.78 |
| Steam gen. per kw.h. gen......lb. | 13.1 | 15.37 | 14.8 | 17.18 |
| Steam gen. per lb. of coal......lb. | 8.5 | 8.55 | 8.31 | 8.60 |
| Coal used....................lb. | 6,522,900 | 6,892,700 | 48,596,100 | 40,324,600 |
| Coal used per kw.h. gen.......lb. | 1.53 | 1.8 | 1.78 | 2.0 |
| Coal used per kw.h. output....lb. | 1.62 | 1.938 | 1.95 | 2.19 |
| Plant thermal efficiency gross..% | 18.5 | 15.8 | 16.0 | 14.2 |
| Plant thermal efficiency net....% | 17.5 | 14.45 | 14.6 | 12.8 |
| Max. load on whole system...kw. | 12,400 | | | |
| Percentage of this supplied from Grand Lake................ | 71.0 | | | |
| Percentage of system requirements supplied from Grand Lake........................ | 84.0 | | | |

### Appendix II

Grand Lake Generating Station

Summary of operating costs for months of October, 1935 and 1936

| | October 1936 | October 1935 | Cumulative 1936 | Cumulative 1935 |
|---|---|---|---|---|
| Coal cost...................... | $9,457.65 | $8,572.25 | $70,321.30 | $59,509.60 |
| Coal cost per kw.h. generated..c. | 0.24 | 0.26 | 0.258 | 0.295 |
| Operating wages................ | $2,256.58 | $2,066.86 | $24,416.50 | $25,643.00 |
| Operating materials............ | 492.16 | 834.29 | 3,717.64 | 3,585.81 |
| Operating miscellaneous expenses | 579.40 | 260.20 | 3,447.23 | 2,508.61 |
| Administration................. | 470.75 | 721.48 | 7,681.28 | 7,767.44 |
| Total operating cost........... | 3,798.89 | 3,882.83 | 39,262.65 | 38,504.86 |
| Total operating cost per kw.h. generated...................c. | 0.089 | 0.118 | 0.144 | 0.19 |
| Interest and sinking fund...... | $7,729.45 | $4,664.09 | 875,350 61 | $57,731.82 |
| Interest and sinking fund per kw.h. generated............c. | 0.18 | 0.142 | 0.276 | 0.285 |
| Maintenance:— | | | | |
| Fuel handling and preparation. | $1,135.88 | $420.17 | $5,810.00 | $2,172.87 |
| Feed water equipment........ | 105.83 | 48.62 | 459.02 | 434.23 |
| Fans and ducts............... | 105.82 | 48.62 | 372.49 | 306.75 |
| Boilers and furnaces.......... | 664.43 | 626.00 | 2,491.50 | 3,407.70 |
| Building and site............. | 125.83 | 48.62 | 556.00 | 634.10 |
| Turbines and auxiliary........ | 178.83 | 420.17 | 871.59 | 2,035.82 |
| Electricity and switchboard... | 160.92 | 27.43 | 520.50 | 883.15 |
| Total....................... | $2,477.81 | $1,639.63 | $11.071.39 | $10,316.12 |
| Kilowatt hours generated........ | 4,277,700 | 3,283,700 | 27,226,200 | 20,204,100 |
| Steam generated (1,000 lb.)...... | 56,133 | 50,478 | 402,596 | 346,952 |
| Coal cost prepared..............c. | 0.178 | 0.183 | 0.2 | 0.21 |
| Steam cost per 1,000 lb.........c. | 34.2 | 35.3 | 40.8 | 43.6 |
| Energy cost per kw.h. generated.c. | 0.528 | 0.572 | 0.72 | 0.824 |
| Total station maintenance per ton of fuel.....................c. | | | 45.8 | 51.3 |

### Appendix III

Typical Run of 800-hp. Steam Generating Unit (No 3 Boiler)

During week ending February 27th, 1937

| | |
|---|---|
| Steam generated................ | 9,327,000 lb. |
| $CO_2$........................... | 14.1 per cent at 290 per cent rating |
| Hours run...................... | 131.05 |
| Coal........................... | 1,126,600 lb. |
| Mill power..................... | 9,960 kw.h. |
| Mill power..................... | 76 kw. |
| Mill power consumption......... | 18.5 kw.h. per ton |
| Fan power...................... | 7,820 kw.h. |
| Fan power...................... | 60 kw. |
| Fan power consumption.......... | 13.8 kw.h. per ton |
| Steam per pound coal........... | 8.3 lb. |
| Feed temperature............... | 265 deg. F. |
| Pressure....................... | 440 lb. per sq. in. |
| Temperature.................... | 645 deg. F. |

Coal varies up to 6.5 per cent moisture with probable B.t.u. 11,500 average. It is impossible to tell which coal is being burned unless the run ends with the bunkers empty which is impossible in central station operation.

### Appendix IV

Typical Run of 6,250-kw. Parsons Turbo-Generator

During week ending February 27th, 1935

| | |
|---|---|
| Steam used.............................. | 10,832,000 lb. |
| Hours................................... | 167.08 |
| Kilowatt hours.......................... | 893,800 |
| Steam per kilowatt hour, including feed heating and evaporator............ | 12.15 lb. |
| Coal per kilowatt hour—gross........... | 1.405 lb. |
| net............ | 1.488 lb. |
| Circulating and extraction pumps....... | 5,797 kw.h. |
| | 35 kw. |
| Feed pumps.............................. | 14,211 kw.h. |
| | 85 kw. |

# The Use and Production of Coke in Canada

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—Sketching the earlier situation as regards gas-coke production in Canada, particularly for domestic use, the author describes the measures taken by the Dominion Government to encourage the use of Canadian coals in the manufacture of by-product coke, and explains the nature of the competition which Canadian producers have to meet.

The first use of coke in Canada was coincident with the establishment of artificial gas plants in the older and larger cities in eastern Canada. This coke was called "gas-house" or "retort" coke. Little attention was paid to its quality by the makers, who considered it to be a residue, a by-product, in the manufacture of coal gas. It was sold in territories adjacent to the point of manufacture for whatever price it would bring. Wood was then the principal fuel used for domestic heating. Later, wood was largely supplanted in the cities and towns of Ontario, Quebec and New Brunswick by American anthracite coal. "Gas-house" or "retort" coke, strictly limited in quantity as it was by the amount of gas manufactured, remained a very minor factor in national fuel economy. It was not suitable for metallurgical purposes.

### Coke for Metallurgical Use

As the metallurgical industry developed, first in the melting of metals for foundry purposes, and later for the smelting of ores in Ontario, Nova Scotia and British Columbia, coke was imported, especially into Ontario, from the United States. No other source of supply was available.

The first by-product coke ovens in Canada were built primarily to produce metallurgical coke. Those at Sydney, N.S., and those at Anyox, B.C. (the latter now shut down), used local bituminous coals. Those constructed at Sault Ste. Marie, Ont., for the Algoma Steel Corporation and at Hamilton, Ont., for the Steel Company of Canada, naturally use American bituminous coal on account of their geographical location. The gas produced by these coke-ovens is used almost exclusively by the metallurgical companies themselves; but in their operations gas is not a necessity. It is only a useful convenience or by-product. Hence the use-value to them is that of coal or other fuel which would be consumed if no gas were available. The coke too small for metallurgical use formerly was largely used for steam generation. Only a very small quantity was sold for domestic heating.

### Coke for Domestic Use

The first use of coke as domestic fuel, aside from the small quantities produced by the gas companies, was in Ontario. It was introduced by owners of by-product coke-ovens in Detroit.

Good by-product coke has practically the same qualities as the very best grades of American anthracite. It is cheaper and it is a satisfactory substitute for anthracite which by 1900, in cities at least, had come to be considered almost a necessity.

In ensuing years the quality of anthracite steadily became worse. Actual shortages occurred from time to time due to labour disputes in the mining regions of northeast Pennsylvania, then the only available source of supply. Several times there was even danger of an embargo on the export of anthracite from the United States to Canada. In 1923, the Pennsylvania anthracite reserves were estimated at thirty-six years' consumption. Anthracite prices became much higher.

About this time the Dominion Government took cognizance of the serious situation and of the resulting hardship in the "acute fuel area." It made thorough investigations which resulted in the conclusions that the situation could be improved, even if not wholly cured, by a more widespread use of coke as a substitute for anthracite, and that the coke should be made in Canada, preferably from Canadian bituminous coal, but even if the coal had to be imported, the coke should be made in Canada.

The demand for coke in Ontario was growing rapidly. It could not be met by Canadian steel and gas companies and so, naturally, extensive imports were made. They originated in American points of production on or near Lake Erie, where large supplies had become available —thanks to the rapid expansion of the American by-product coke industry. This condition and the known attitude of the Government led to the formation of the Hamilton By-Product Coke Ovens Limited, which in 1924 put into operation at Hamilton, Ontario, the first merchant by-product coke plant in Canada, i.e., one not owned by a company using most or all of the coke and gas made, in its own metallugical operations. It had to depend for its coke market on domestic and industrial (other than metallurgical) consumers, and it had to sell its surplus gas, some 35 to 40 per cent of the total evolved by coal in the coking process. The gas was bought by the local gas company which mixed it with natural gas for distribution in and about Hamilton.

It is most important to understand this dual necessity, which is the fundamental commercial difference between *merchant* by-product coke-oven plants and those owned by metallurgical companies. The steel companies themselves consume most or all of the two principal products, coke and surplus gas. The merchant plant cannot be established or, if established, cannot continue to exist without the sale of both coke and gas to others.

The Government was greatly interested in this undertaking and took measures to aid its success, in the hope that others would be encouraged to established similar plants elsewhere in Canada.

As a result the Hamilton By-Product Coke Ovens Limited doubled its plant in 1926; a by-product recovery coke-oven plant was completed in 1924 by the Winnipeg Electric Company in Winnipeg and in 1928 a much larger one, having a capacity of 400,000 tons of coke per year, was constructed just outside the city of Montreal by the Montreal Coke & Manufacturing Company. These plants were built in conformity with the publicly expressed policy of the Dominion Government. They are fulfilling the purposes for which they were constructed and are valuable assets to the country.

The steel companies having by-product coke-ovens also aided materially in providing additional domestic coke supplies by operating their coke plants at rates often far greater than would have sufficed for their own metallurgical coke needs, and by altering and increasing their coke screening equipment so as to be able to make as much domestic coke as possible.

Some gas companies also did their utmost to increase domestic coke supplies—the British Columbia Electric Power and Gas Co. Ltd., by building a by-product recovery coke-oven plant in Vancouver in 1931; the Quebec Power Company, a new coal gas plant in Quebec in 1929; the Nova Scotia Light and Power Company of Halifax, a new coal gas plant in 1927; and the Ottawa Gas Company by converting their already installed retort equipment into coke-ovens.

## THE USE OF CANADIAN COAL FOR DOMESTIC COKE PRODUCTION

### Objects of Fuel Investigations

The Dominion Government investigations above referred to had two aims, viz., to free Canada from dependence on Pennsylvania anthracite and to find substitutes for it, if possible of Canadian origin.

### Possibilities

There were only three possibilities which gave any hope of fulfilling both objects. These were:—

- Utilization of peat and/or lignite;
- Production of coke from Canadian coal by low temperature distillation;
- Production of coke from Canadian coal by the by-product recovery coke-oven process.

There is no need to say more about the first two than that they were thoroughly investigated and found impracticable under present Canadian conditions.

The third seemed to offer greater promise. Coke made in by-product recovery coke-ovens from 100 per cent Canadian coal was being used in a small way in some areas in the country. Large reserves of coking coals occur in Canada, though unfortunately principally far from the principal centres of population. It was thought that under the circumstances of national necessity existing in the period between the close of the war and 1925 these difficulties might be overcome with financial and other assistance from the Dominion.

### The First Duncan Report

These ideas are well summarized in the report of the first Duncan Commission dated January 8th, 1926, "Report of the Royal Commission Respecting Coal Mines of Nova Scotia," 1925, Halifax (pp. 57, 58 and 59).

The Commission, which was considering the situation principally from the standpoint of increasing Maritime coal production, took a very optimistic view of the potentialities. Its conclusions follow closely those contained in Publication No. 5 of the Dominion Fuel Board—"Coke as a Household Fuel in Central Canada," Ottawa, 1925 (pp. 136-138). These tentative plans contemplated the construction of seven coke plants. They were to be located in Quebec, Montreal, Ottawa, Toronto, Hamilton, Port Colborne and London. Their potential consumption of Canadian coal was estimated at 1,904,000 tons per year with a resulting production of 1,376,000 tons of domestic coke. As the necessary coal was thought to be available from existing mines in Cape Breton, the Commission recommended that the provincial government should enter into active co-operation with the Dominion Fuel Board further to explore the possibilities of immediate development.

### The Domestic Fuel Act

As a result of these recommendations and of similar related efforts, the Dominion Government passed the Domestic Fuel Act—17 George V, Chapter 52, which received assent April 14th, 1927.

The Act provided for the payment, under certain conditions, of subsidies based on the capital cost of the works, to private companies or to municipalities and other public corporations erecting carbonizing plants to make domestic coke. In order to receive the subsidy, the carbonizing equipment had to be so constructed that 70 per cent of Canadian mined coal could be used. The subsidy might extend to a term of fifteen years. Advantage of it was not to be taken after June 30th, 1932.

### Results of Domestic Fuel Act

The results of this legislation were far from what had been hoped. So far as eastern Canada is concerned, two small plants were built under it—one at Halifax, N.S., and one at Quebec City, between them using only some 35,000 tons of Canadian coal, instead of seven plants using 1,904,000 tons.

In 1928 the plant of the Montreal Coke & Manufacturing Company with a capacity of over 500,000 tons of coal was completed. This company did not make application to benefit under the Act although the subsidy it could have received would have been around $225,000 per year. Obviously the conclusion that the conditions for receiving the subsidy could not successfully be met, was reached only after mature and careful consideration.

One other undertaking qualified for and is receiving the subsidy, viz., that of the British Columbia Electric Power and Gas Company, Ltd., in 1931 in Vancouver. This, of course, had no bearing on the situation in the "acute fuel area," Ontario and Quebec.

### Why the Domestic Fuel Act Fell Short of its Objective

There was great disappointment, specially in Nova Scotia, that the results of the Act came so far short of what had been anticipated. Much agitation arose for the enactment of compulsory or punitive measures. There were even accusations of deliberate unwillingness on the part of potential or already established manufacturers to use Nova Scotia coal for coke making. All this, however, came from lack of knowledge of the severity of competition in quality as well as in price among the various kinds of domestic fuels, which has to be met by coke makers, and from the faulty premise that any kind of coal that cokes will make a fuel satisfactory to all householders.

### Satisfactory Coals for Domestic Coke Manufacture

Beside the property of coking, there are three other essential qualities coal must have to make it available as the raw material for domestic coke:

- It must be of the proper quality to produce the desired kind of coke;
- It must store in quantity for long periods without damage from heating;
- It must be purchasable at a price which will permit the manufacture of coke at a cost which makes successful competition with other fuels possible.

### Efforts to Get Satisfactory Coal in Nova Scotia

The Nova Scotia coal available at the time of the passage of the Domestic Fuel Act filled none of these three requirements so far as the Montreal Coke & Manufacturing Company was concerned. This is the reason no attempt was made to take advantage of the Domestic Fuel Act. This Company had confirmed by large scale practical experiments in 1930—part of the cost of which was defrayed by the Dominion Government—its previous conclusions on the subject. However, it continued to try to find some way which would permit the purchase of at least a substantial part of its coal requirements in Nova Scotia. It shared actively in the attempts of the Dominion Coal Company, aided by the Technical Staff of the Division of Fuels, Department of Mines, to effect a satisfactory solution of the problems of quality and storage. Without this, no price—no matter how low—could be attractive.

### Technical Success

These experiments were eventually successful. By special methods the Dominion Coal Company was able to prepare from certain mines coal of such a quality that at least 35 per cent of it could be used with mixtures of other coals to produce the desired quality of coke. The storage of this specially prepared coal was also satisfactory. Its utilization then became a matter of cost.

### Employment Given by the By-Product Coke Industry in Canada

In 1934, the Montreal Coke & Manufacturing Company produced 393,000 tons of coke, about one-sixth of the Canadian total. In this year its total disbursements for Canadian labour and materials were $2,672,000.

Its payrolls were $500,000. This sum is equivalent to approximately one million man hours or 125,000 man days of labour. Taking three hundred working days per man per year, direct employment was given to 417 persons.

This is by no means the total Canadian labour to be considered. In 1934 the company used 185,000 tons of Canadian coal which had it not been for its operations would not have been mined. Taking the approximate output per man per day in Nova Scotia mines at two tons, 92,500 man days of employment resulted. At two hundred and thirty working days at the mines in 1934, employment for 400 men resulted.

Twelve Canadian owned and Canadian operated vessels each having a crew of twenty-one men were employed to carry the coal used by the Montreal Coke & Manufacturing Company from Nova Scotia and from ports of Lake Erie and Lake Ontario to its plant at Ville Lasalle, P.Q. Therefore, in the direct operation of the boats 252 men were employed for the season of navigation.

The total of these three items is 1,069 men. Assuming that the remainder of the expenditures made up of smaller items gave as much employment per dollar as those just cited, the Montreal Coke & Manufacturing Company in all, directly and indirectly, gave employment to about 1,540 men in Canada. If the other five-sixths of the coke industry in Canada employed labour in the same ratio, the total for the industry would be around 9,000 persons.

## THE NATURE OF COKE COMPETITION IN CANADA

Sellers of coke, whether it be of Canadian or foreign origin, under ordinary circumstances naturally try to sell it for its value.

The market value of coke is governed by the selling price of competitive fuels. In the populous sections of Central and Eastern Canada the determining fuel has been anthracite coal. Formerly American anthracite was decisive but now foreign anthracite also has weight.

### How Coke Prices Are Established

The Canadian coke producer in deciding upon the price to ask for his product first considers the price of anthracite and makes up his mind how much less he must quote in order to do business. When the coke is to be sold at a distance from the point of production he deducts from this amount the cost of transportation and other expenses incident to moving the coke from his plant to the point to which it is to be shipped. The remainder is all that he can receive. If it is too low to be attractive he names a higher price and resigns himself to the possibility of not doing business at the point in question.

This is a normal economic way of arriving at prices. Insinuations and statements that Canadian manufacturers of coke are charging outrageous prices are without foundation. To sell an article for its value is not extortion nor profiteering. The consuming public has ample and automatic protection against exploitation in the price of coke because there are everywhere several other fuels available if too high a price is asked for coke.

Since coke cannot be manufactured at every point where it is consumed, all producers take different prices when the cost of transportation to the point of consumption is different. Generally, the greater the distance from the point of production the less the manufacturer gets for his coke. The market nearest the point of production is almost always the most important and most profitable. Remote markets are desirable only when production exceeds local demand.

### Importations of European Coke

Competition of any consequence due to the importation of European coke first occurred in 1931 when Great Britain abandoned the gold standard and the pound sterling fell to as low as $3.70. British coke manufacturers were quick to see the possibilities and looked eagerly to St. Lawrence ports as an outlet. Montreal was particularly attractive because of its size and because a well established coke trade already was in existence. Indeed several cargoes of English coke were put into Montreal at prices Canadian manufacturers could not meet permanently. The extent and the duration of this menace were not known, so one Canadian coke maker actually decreased its operations to about 60 per cent of its capacity. British coke was duty free, as it is now. Had there been a duty of $1 per ton, coke manufacture in Montreal and Canadian enterprises serving it would have proceeded at a normal rate.

There is at present increasing actual competition and vastly greater potential competition from Continental Europe. This is coming to some extent from Poland and Belgium, but more especially from Germany. It is non-economic in the sense that it is not made possible by cheaper production, but is the result of the dire need these countries have for foreign exchange with which to purchase goods they are unable to produce or to find substitutes for at home.

The prices of exports from these countries have simply nothing to do with costs of production or internal prices, nor with the motive of profit on which all trade is ordinarily based. Losses on such sales are not borne by individual industries or manufacturers, but are spread over the whole national economic structure because they are incurred as a national necessity. The extent to which this condition can develop is well shown by the London dispatch appearing in the "Montreal Standard" of November 22nd, 1936, which reads as follows:—

> "London, Nov. 21—On the Thames wharves first consignments of 100,000 tons of foreign coke are waiting to be unloaded.
>
> In the mining districts of South Wales, Scotland, and Durham, miners and coke-oven workers have just been told that there is no work for them.
>
> To produce this 100,000 tons of coke at home would employ 330 British miners and 330 subsidiary workers. In other words, this cargo in the Thames throws 660 men idle.
>
> Counter plans have been laid by the coal owners and distributors to stop this foreign coke buying. Representations are being made to the Minister of Mines and the subject will be raised in Parliament.
>
> It is stated that no justification can possibly exist for importing a single cargo of coke while thousands of British miners are still without work, and while sufficient supplies of suitable fuel are easily available."

Such occurrences are bound to impress us forcibly that private manufacturers, who are necessarily in business to make profits, have no chance whatever to compete with the whole resources of a foreign government which has real or fancied national needs as a price mover. Consequently, it is for those who direct and formulate national policies to decide what measures to take in face of conditions which have been almost unknown up to the present time.

Conclusions

The studies on which the foregoing is based lead to the following definite conclusions:—

1. The governmental policy designed to free the "acute fuel area" from almost complete dependence on Pennsylvania anthracite is sound.
2. The governmental policy of encouraging the establishment of by-product recovery coke-oven plants to aid in attaining this end has been well justified.
3. The by-product recovery coke-oven industry is a distinct national asset because of its domestic fuel production, because of its direct and indirect employment of Canadian labour and because of its consumption of Canadian raw and finished materials, especially of Canadian mined coal.
4. The sympathetic attitude of the government toward this industry ought to be continued.

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# Some Observations on the Use of Bituminous Coal as Locomotive Fuel

*John Roberts,*
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**Paper presented before the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—A brief account of the conditions of combustion in locomotive boilers and the method of selecting coal for locomotive use.

The purchasing, distribution and economical consumption of coal on any large railway system presents a vast and complex problem. Its vital importance may be gauged from the fact that the total coal bill for the Canadian National system—all inclusive—for the year 1936, amounted to over $18,000,000, and this figure does not include the cost of "on company's service" haul.

While there is an abundance of coal within the Canadian borders, nature unfortunately located the coalfields in the extreme east and extreme west, leaving the central provinces with no domestic source of supply. The Canadian National policy has been to extend the use of domestic coal to the economic limit and Maritime Province coal is being used from the Atlantic coast to Toronto and Cochrane, and western Canadian coal from the Pacific coast to Winnipeg and sometimes even farther east.

The quality of coal obtained from the different seams varies through a very wide range. There are coals rating about 14,500 B.t.u., 37 per cent volatile, less than 4 per cent ash and between 1 and 1½ per cent sulphur, which compare favourably as locomotive fuel with the best on the continent, and from this peak they vary all the way down the scale to a quality which we would much prefer to leave underground until someone happens to need it.

In order to distribute the various grades of coal from the mines to the points of consumption in such a manner as to give the best results, close co-operation between the mechanical department and the fuel department of the railway is essential, and a great deal of study has been given to this phase of the question by both departments during the past fifteen years. By means of evaporation tests under service conditions the mechanical department have rated the relative fuel value of every grade of coal used for firing locomotives, from coast to coast. In the first place a very good grade of coal was selected, tested and given an arbitrary rating of 100 per cent. As the other grades were tested the results were compared with the 100 per cent test and a separate fuel value rating given to the coal from each mine contributing to the railway's requirements. The quality of coal from any mine is liable to vary over a period of years and, when any change is noticed or suspected, check tests are made and the rating varied, if necessary, to keep all rated comparative values in line with present day quality.

One of the principal functions of the fuel department is to select the right coal for each terminal, and having all coal test reports and ratings at their disposal is of great assistance in making the best selection. In the first place the grade of coal selected must be suitable for the class of service required and, assuming this condition as having been met, the next consideration is economy. At terminals which are located at a considerable distance from the source of supply, the cost of haulage is a large percentage of the final cost of the coal loaded on the tender. Speaking in a general way then, the problem of the fuel department is to take into consideration the pit-head cost, the hauling and handling cost and the percentage rating of the fuel, and then supply a coal suitable for the class of service required, and which will give the maximum number of pounds of steam per dollar of expenditure.

The burning of different qualities of coal, with widely varying characteristics, in locomotive service, presents an almost unlimited array of problems, and these difficulties have to be overcome without interruption of service. Some coals will clinker the grates, some will build up ash at a rapid rate, some will plaster the back tube sheet with slag, some show a tendency to plug flues, others to plug spark arrester netting, and any of these troubles will kill an engine in a very short space of time, unless the conditions are watched closely.

There are few engineers outside the field of the railways and locomotive builders who realize what a marvellous piece of equipment is the modern locomotive boiler. When limiting dimensions and weights are taken into consideration together with tremendous capacity, rapid flexibility and withal a very respectable efficiency, it must be admitted that there is nothing just like it in the whole field of steam generation. The steam demand of the engine on the boiler may vary as much as 3,000 h.p. within a few minutes, and the rate of combustion and evaporation must vary coincidentally with the demand, in order to maintain a constant steam pressure.

The evolution of the locomotive boiler has been a gradual process during the past hundred years and, while the fundamental principles with regard to arrangement of grates, firebox, barrel and smokebox still remain, the proportioning and construction of the present day boiler bears little resemblance to the boiler of a few years ago.

Grate areas have been increased to bring the maximum combustion rate per square foot of grate within the desired limit; air openings in grates have been greatly reduced to combat the wasteful effect of excess air; firebox heating surfaces and combustion chamber volumes have been enlarged to obtain the maximum benefit of radiant heat; brick arches have been introduced to increase the length of the flame way, to direct the gases evenly over the whole tube sheet area and improve the distribution of radiant heat to the firebox and combustion chamber walls; arch tubes and syphons have been applied to improve water circulation and further increase the absorption of radiant heat; mechanical stokers have been developed which will maintain a thin fire evenly spread over the total grate area, and drafting appliances so proportioned as to induce the required flow of air through the grates with the least possible back pressure on the engine. Apart from the steam generating equipment there are other important economy devices such as feed water heaters and superheaters, which assist materially in keeping combustion rates within the economical range, and the cumulative effect of all these refinements in design is shown in a marked improvement in fuel performance.

Calculated on the basis of fuel consumption per 1,000 gross ton miles, the improvement in fuel performance on the Canadian National system from 1923 to 1936 amounted to over 22 per cent, notwithstanding the adverse effect of higher operating speeds. The average freight-train speed during the same period increased by over 39 per cent. The records of the Canadian National system, as at present constituted, only date from 1923 and there is no doubt that, if the records were available for the previous ten years, the figures would be even more impressive.

Combustion conditions in locomotive service are entirely different from those in any other type of steam generator, and on this account a coal which may give good results in other classes of service may be unsuitable for locomotive use. The comparative ratings assigned to the output of various mines are therefore based on the results of road tests rather than on calorific values and analyses. This statement is not intended to convey the impression that the laboratory figures have no value. The heat content and analyses are always obtained, and in many cases the laboratory tests are carried through to the ultimate analysis, ash analysis, fusing point of ash, etc. These figures give definite clues to the general characteristics of the fuel and to whatever troubles may be anticipated in service. For instance, a high sulphur content will always indicate trouble from the formation of clinker in the firebox and also liability to spontaneous combustion in the storage pile. A high ash content is never desirable in coal for any purpose and least of all for locomotive service. If the percentage of combustible volatile is low, it indicates a short-flame coal, which will not permit of taking full advantage of the increased combustion volume and firebox heating surface of the modern locomotive boiler. The more information the railway officer has of the characteristics of the grades of coal he has to use, the better position he is in to overcome any troubles which may develop, but, as stated before, the final percentage ratings are based directly on results obtained under service conditions.

Perhaps the most remarkable characteristics of locomotive combustion conditions are the very high maximum combustion rates, high maximum firebox temperatures and the capability of varying these rates and temperatures in instantaneous response to variations in the steam demand upon the boiler. The use of the main exhaust as a jet through the petticoat and stack, to induce the necessary draft through the fuel bed, is the simplest, most effective and in fact the only satisfactory method ever evolved of maintaining a constant balance between the supply and demand for steam. The elementary principle was used on George Stephenson's "Rocket" and on this account there have been periodical outbursts of criticism of what is regarded by the critics as an antiquated method. The idea generally advanced is that a steady, controlled draft, such as might be produced by a fan, would be less liable to tear the fire, thus effecting a reduction in spark losses, etc. Experiments have revealed the rather surprising fact that a pulsating draft is a decided advantage when burning coal under locomotive operating conditions. The steady draft required to support a given rate of combustion is considerably higher than the average of a pulsating draft, in fact the steady vacuum will often run higher than the peaks of the pulsations. Under these conditions it will be readily understood that, when a steady draft picks up the fines from the fuel bed, they whirl right out of the stack without any pause, whereas when the fines are picked up at the pulsating peaks, the tendency is to drop back, and a considerable proportion will be burned in suspension over the fire. It is absolutely essential, however, that the pulsations be reasonably mild and perfectly even, as there is nothing which will tear a fire in holes quicker than uneven exhaust beats from the engine.

The problem of induced draft on locomotives is not one that can be solved by mathematical methods. Various empirical formulae have been used through the various stages of development of the locomotive boiler, but perhaps the most valuable contribution in recent years is the report which was issued last year by the Locomotive Construction Committee of the Association of American Railroads. The practice outlined in this report was based on the results obtained from several years of experimental work on the Chesapeake and Ohio Railway, and it was found possible to recommend a definite proportioning of the various gas passage areas between the firebox and the stack. By this method the area over the brick arch, the area under the table plate, the area under the draft sheet, the net area through the smokebox netting and the cross-sectional area of the stack are all based on the net gas area through the tubes and flues, and results obtained to date on engines with the recommended proportioning have been entirely satisfactory.

In addition to providing for the efficient generation of steam, there are other difficulties which have to be faced, such as fire hazard and smoke nuisance. To support combustion, and also to keep grate bearers and grates reasonably cool, a free flow of air is essential through the ash pan. It is often a difficult matter to provide for unrestricted air flow in such a way as to prevent the possibility of live coals dropping to the track or being blown out of the pan by a strong cross wind, but nevertheless it has to be done. Any sparks which are ejected from the stack must be broken up to such a size that they will be dead before they reach the ground. The small cinders which are drawn through the flues cannot be allowed to accumulate in the smokebox and they are therefore kept in a constant swirl by a strong draft directed along the bottom of the smokebox, to be broken up by the spark arrester netting and discharged to the atmosphere. These complications increase the difficulty of designing a free steaming boiler but it is essential that such conditions be met and there is no desire to side-step the issue.

The emission of black smoke was a common, every day occurrence in the old days of narrow fireboxes and banked fires but, with the thin fires and large grate areas and combustion chamber volumes of present day practice, there should be no difficulty in keeping the stack clear, provided the coal is of such quality that a thin fire can be maintained throughout the run. The gospel which was preached to the old-time engine crews, that black smoke meant waste, and a clear stack indicated economy, probably did a lot of good, but without proper qualification it might be very far from the truth. Black smoke certainly indicates incomplete combustion, but the number of B.t.u. wasted in the unconsumed combustible given off with the smoke does not approach the waste of B.t.u. which is possible with large volumes of excess air and a clear stack. The stack should be clear at all times, which means that sufficient air must be provided to support complete combustion; the excess air, however, must be kept down to the practical minimum and this is accomplished by restricting the percentage of air opening through the grates to a fraction of what it was a few years ago.

Taking into consideration the steady improvement in combustion conditions, the coal operators would probably like to know why the railways, during the past few years, have been insisting on an increasingly better grade of fuel. The answer is that exigencies of traffic are constantly becoming more severe, trains are heavier, running times are shorter and avoidable delays are not tolerated. The more the locomotive is improved, the more work is expected from it and, unless a reasonably good grade of fuel is available, it is impossible to keep traffic moving at the speeds which are required today. The use of an inferior grade of coal becomes increasingly difficult with faster service; if a clinker forms on the grates, the best a fireman can hope to do with it is to hook it into one of the back corners until he has an opportunity to get it out, and if clinkers form too rapidly a steam failure is sure to follow. If the ash builds up too quickly the fireman can move his grates once in awhile and shake the ash into the pan; the pan, however, has only a limited capacity and, if it should happen to be filled to such a level that the grate bearers become overheated, the results are disastrous.

The shipper is constantly pressing the traffic department for improved service, the traffic department turns the pressure on to the transportation department, who in their turn make increased demands on the mechanical department. The mechanical department make every effort to improve their equipment to meet the situation, but at the same time pass some of their troubles along to the fuel department. The fuel department follow the situation to its logical conclusion by imposing more exacting conditions on the coal operators. The struggle for improvement is unceasing—one cannot afford to stand still as there is always the danger of slipping back. Yesterday's peaks are today's averages, today's peaks will be demanded as tomorrow's averages, and so the battle goes on.

# The Burning of Low Rank Alberta Coals

## Combustion and Control

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—Contains brief introductory notes on coal classification and analysis, with data and charts relative to combustion, referring particularly to Alberta coals of low rank.

This paper is planned to enable combustion engineers to become more familiar with recent developments in the methods and conceptions of coal analysis, and with their significance in combustion problems, as well as to supply them with data, equations and charts relative to combustion. The title of the paper limits its range to the combustion of low rank coals, but it has appeared necessary to study low rank coals by comparison and contrast with high rank ones. It is hoped that the paper will be of general value; but since Alberta possesses a wide range of coals, and the author has access to far fuller details of these than of other Canadian coals, the examples given are entirely, and the charts are largely, based on Alberta coals. Certain phases of the problem have been omitted to reduce probable overlapping with other papers to be presented at the same convention.

### Rank and Grade of Coal

Coals are ranked according to their degree of metamorphism or progressive alteration, in the natural series from lignite to anthracite; a low rank coal has undergone less metamorphism than has a high rank coal. Coals are graded according to their calorific value, ash and sulphur content, screen size, ash softening temperature, etc., that is, in general, according to their commercial value. Low rank coals may be high grade with respect to purity, screen size, etc., but are always low grade with respect to calorific value. A low grade coal may be of either high or low rank.

### Coal Classification

There is no internationally accepted classification of coal by rank, and Canada has not yet adopted any classification. In the United States coals are classified by the fixed carbon in the pure, dry coal and by the calorific value of the pure, moist coal, with some reference to physical properties, according to a specification[1]* of the American Society for Testing Materials (A.S.T.M.). In England coals are classified by the carbon and hydrogen in the pure, dry coal according to Seyler's classification.[10] The Provincial Mines Branch in Alberta[4] classifies coals for statistical purposes as bituminous, subbituminous and domestic, but no specifications have been given for these classes.

### The Coal Band

If charts are prepared to show graphically the composition of a large variety of coals—by plotting carbon against hydrogen in the pure coal as in Seyler's chart, or volatile matter against calorific value of unit coal as in Parr's chart,[5] or dry fixed carbon against moist calorific value of pure coal as in the A.S.T.M. classification, or by many other methods of plotting—the resultant points are found to lie along a band which has a sharp bend. This band is called a coal band. In Figs. 3, 5 and 6, such a band is shown for a number of Canadian coals.

It can be seen that a criterion which cuts across one limb of the band, and is therefore good for classifying those coals, may lie almost parallel to the other limb and is therefore useless for classifying the coals in that limb; this explains why two independent variables, or criteria, have always to be used for a full coal classification. In the same way it will be shown later that combustion factors which differentiate the high rank coals may show little variation in the low rank coals, and vice versa.

### Analyses of Coal

Three types of analyses are commonly made of samples of coal, proximate, ultimate and calorific analyses. The first, which is empirical in character, determines moisture, ash, volatile matter, and fixed carbon. The second, which gives absolute results, determines the actual percentages of carbon, hydrogen, sulphur and nitrogen in coal. The ultimate analysis also includes the ash, and oxygen by difference. The third analysis, also absolute in character, determines the heat value or calorific value of the coal,

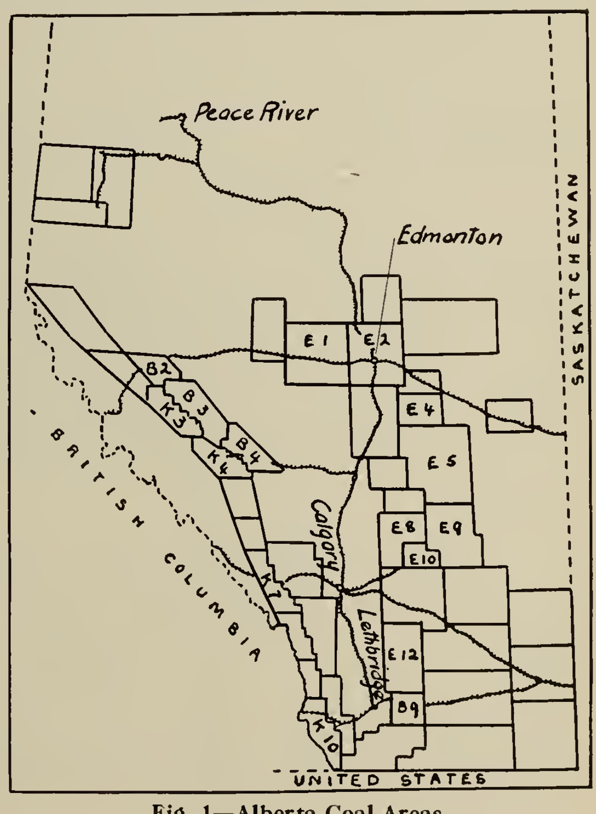


Fig. 1—Alberta Coal Areas.

usually as British thermal units (B.t.u.) per pound of coal burned. The specifications of the A.S.T.M.,[2] with minor modifications, are generally employed in Canadian laboratories.

### Mineral Matter and Ash

All coals contain mineral impurities in greater or less amount, and when burned an ash is left behind. The weight of ash, however, is rarely the same as that of the mineral impurity. It is easy to determine the percentage of ash by burning the coal, but it is almost impossible to

*References to the bibliography at the end of the paper are indicated by superscript numbers, thus [1].

make a direct determination of mineral impurity. The relation between the weight of mineral matter and the weight of ash of any coal can be studied by means of calorific value determinations.

If sugar were mixed with 20 per cent by weight of chalk, its calorific value would be reduced by 20 per cent, but if the ash of this sugar-chalk mixture were determined

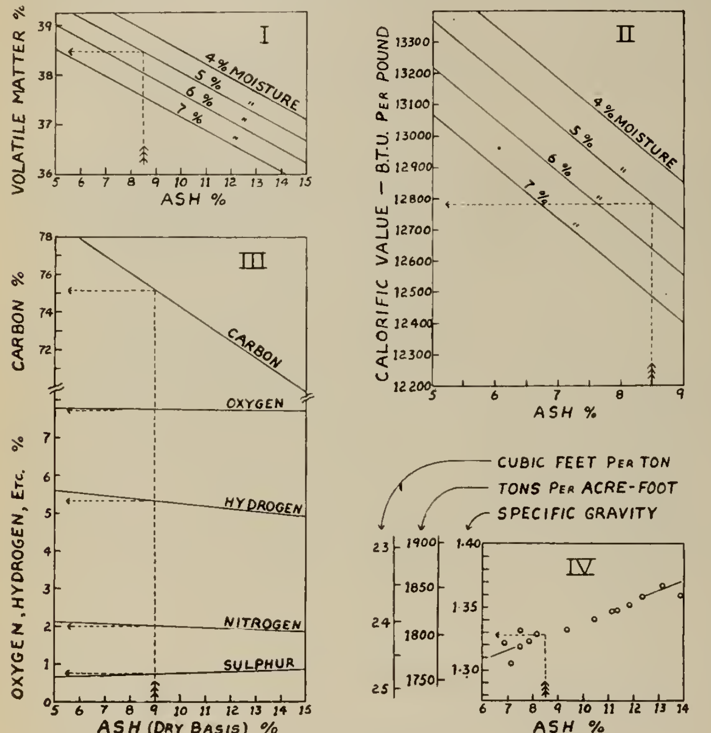


Fig. 2—Coal Charts.

it would be found to be only 11.2 per cent, since 100 parts of chalk when heated, as in the ash determination, lose 44 parts of carbon dioxide and leave behind only 56 parts of lime (ash). It would thus be found that a 20 per cent reduction in calorific value was found in a sugar-chalk mixture showing 11.2 per cent ash; but as a 20 per cent reduction in calorific value must be caused by the addition of 20 per cent of mineral matter to the sugar it is obvious that the ratio of mineral matter to ash is in this case 20 ÷ 11.2 or 1.79.

In the laboratories of the Research Council of Alberta (R.C.A.) a method[14] has been developed in which samples of coal are separated into a number of fractions of varying ash content—floats and sinks—by means of liquids of suitable densities. Each fraction is then analyzed and each percentage of ash plotted against the corresponding B.t.u., both calculated to the dry coal basis. It is found that, within experimental errors, the points lie along a straight line. This line, if extrapolated to the zero ash axis, gives the calorific value of the pure, dry coal; and the mineral matter to ash ratio can be calculated from the slope of the line.

It follows from the above that if two samples of the same dry coal have ash percentages of $A_1$ and $A_2$, and calorific values of $CV_1$ and $CV_2$ respectively, and if the ratio of mineral matter to ash is $F$

then $$CV_2 = CV_1 \frac{100 - FA_2}{100 - FA_1} \quad \text{(I)}$$

Or, if the ash percentages and calorific values are those of moist samples with $M_1$ and $M_2$ percentages of moisture,

then $$CV_2 = CV_1 \frac{100 - (M_2 + FA_2)}{100 - (M_1 + FA_1)} \quad \text{(II)}$$

The factor $F$ varies from coal to coal, but an average value of 1.1 is often assumed. Some determined values are given in the last column of Table II.

It must be noted that although the ratio of mineral matter to ash can be used in calculations of calorific values, the presence of mineral matter in the coal, as distinct from the ash of the coal, may affect other analytical values of the coal in unpredictable ways. Thus the mineral matter may contain a lower percentage of moisture than does the coal, so that the cleaner the sample the higher the moisture. Sometimes the mineral matter contains the higher percentage of moisture, so that the reverse is the case. It is commonly assumed that the difference in weights of mineral matter and ash affects the volatile matter as determined, but not the fixed carbon; this is often not correct. Again, if the mineral matter contains water of hydration not removed in the moisture determination, the hydrogen as determined is not all hydrogen from the coal; similarly carbonates in the mineral matter will increase the determined carbon of the coal. All these factors cause uncertainty in computations based on coal analyses.

The float and sink fractions of coal described above can be subjected to full proximate and ultimate analyses, and the determined values of the different constituents, together with any other available comparable analyses, all calculated to the dry coal basis, can be plotted against the corresponding ash percentages. As before, these points will be found to lie along straight lines, and these lines can be extrapolated to the zero ash axis and thus furnish a good estimate of the complete analysis of the pure coal.

### Capacity Moisture in Coal

All coals contain some moisture which is commonly regarded as inherent in the coal. Since coal mines are frequently wet, and mined coal may be exposed either to rain or to dry air, different consignments of the same coal may show notable variations in moisture content. It might be suggested that it matters little to the consumer whether the water delivered in his coal really belongs there or not, if he has to pay for it, and for its evaporation, in either case. Nevertheless it is useful to know the true, inherent moisture

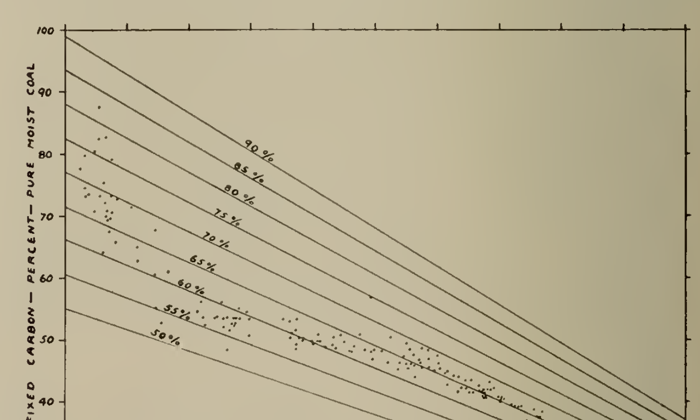


**Fig. 3—Canadian Coal Band and Percentage of Heat in Non-Volatiles.**

of the coal; and this moisture is an important factor in the classification of the coal by rank. The free surface water of a coal also will dry off faster than will the inherent water.

In the work of the Research Council of Alberta the capacity moisture of a coal is defined as the least amount of water in the coal that will show the same vapour pressure as does free water at the same temperature. A simple method has been devised for determining the true or capacity moisture of any coal, in accordance with this definition.[13] In later tables, wherever data with respect to moist coal are given, the values are for coal with its capacity moisture.

### Gross and Net Calorific Values, and the Therm

When coal is burned in a bomb calorimeter, as in the determination of calorific value, the products of combustion are cooled to room temperature and the steam is condensed to water and gives up its latent heat to the calorimeter. In ordinary combustion of coal, on the contrary, the products

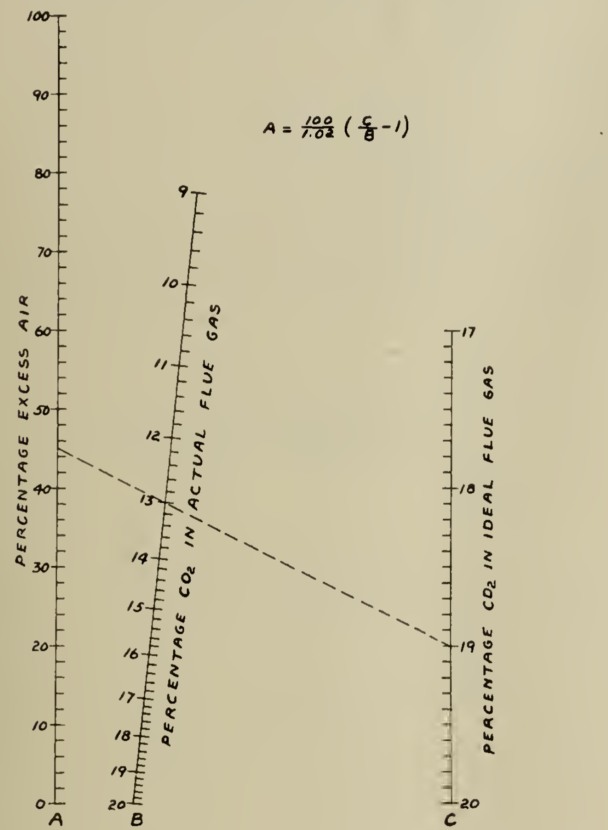


Fig. 4—Excess Air in Combustion of Coal and $CO_2$ in Flue Gases.

of combustion escape up the chimney at too high a temperature to permit the condensation of the steam; there is thus lost not only the sensible heat of the gases but also the latent heat of the steam. A boiler maker, in tests of the efficiency of his equipment, may feel that he is correctly charged with the loss of sensible heat and yet resent being charged with the loss of latent heat that he has no reasonable chance to recover even in part. Two forms of calorific value therefore are recognized—gross calorific value in which the products of combustion are cooled to ordinary temperatures (about 60 deg. F.) and the steam condensed to water, and net calorific value in which the products of combustion are cooled to ordinary temperatures but with the steam uncondensed. The gross values are generally used in Canada, but the net values give a better picture of the relative commercial values of different types of coal, and are often used in other countries.

The net calorific value of a coal may be calculated from the determined gross value by subtracting 94 B.t.u. per pound for each one per cent of hydrogen in the coal as fired. The percentage of hydrogen must include both the hydrogen of the coal itself and the hydrogen of the accompanying water. The last column of Table IV shows the approximate percentage of the gross calorific value to be subtracted from that value to give the net calorific value of each coal cited, when burned with its capacity moisture. With a natural gas this reduction may be over ten per cent, so that the correction is of considerable importance in considerations of the relative values of coal and gas as fuels. It also will be shown later that true combustion relations between the lower rank coals are only shown when the net heat value is taken.

Since the ordinary unit of heat, the B.t.u., is rather small a larger working unit has been created and called a therm; this value is used in one of the tables. The therm is equal to 100,000 B.t.u., and is approximately equal to 30 kw.h. or to 40 hp.h.

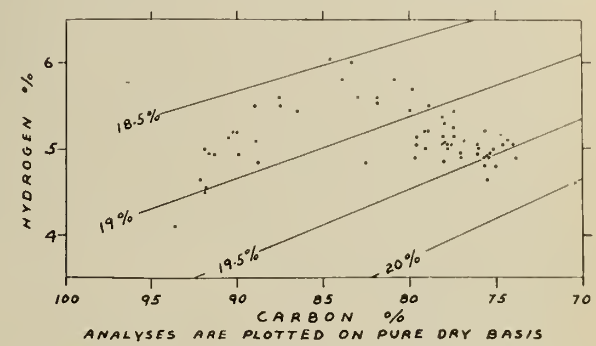


Fig. 5—Canadian Coal Band and Iso-Carbon Dioxide Lines for Dry Flue Gas.
(Plotted on Seyler's Classification Basis.)

### Ignition Temperature of Coal

This can only be an empirical value, as the time factor plays an important part in the ignition of coal. Thus a pile of coal out of doors may catch fire, but no one would suggest that the ignition temperature of any coal is as low as the temperature of the atmosphere. Wheeler has devised a test[15] in which dry, powdered coal is slowly heated in a stream of dry oxygen and the temperature measured at which rapid oxidation commences. This temperature is capable of exact determination, but it might better be regarded as the temperature of acute danger in a stock pile than as the temperature of ignition. An R.C.A. method[6] has been devised and constructed by H. Stansfield for measuring the lowest temperature of an air current in which small particles of the raw coal will catch fire within a couple of minutes. This temperature is not capable of exact determination, but it does indicate the temperature at which open combustion will commence. Some values by the Wheeler method are shown in column 5 of Table IV. No values by the R.C.A. method are available for tabulation;

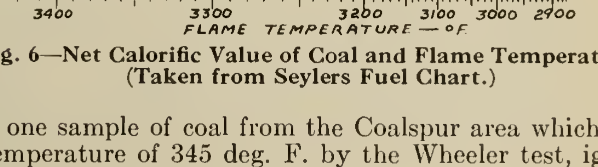


Fig. 6—Net Calorific Value of Coal and Flame Temperature.
(Taken from Seylers Fuel Chart.)

but one sample of coal from the Coalspur area which gave a temperature of 345 deg. F. by the Wheeler test, ignited in air at 705 deg. in the R.C.A. test.

### Oxidizability and Storage of Coal

This large subject can hardly be more than mentioned. The R.C.A. has examined many methods for evaluating the oxidizability of coals, but only one method[7] will be described. An air-dried sample of fresh coal is ground for about one hundred and twenty hours in a ball mill filled with air, and maintained at exactly 86 deg. F. Oxygen enters the mill through a gas meter to replace the oxygen absorbed by the coal, and the volume absorbed is thus calculated. The measurements with some coals are complicated at the beginning of a test by the evolution of occluded gas from the coal. A standard procedure was therefore adopted for evaluating oxidizability by the oxygen absorbed by the coal between the twenty-fourth and the ninety-sixth hour, expressed as a weight percentage of the pure, dry coal. Values obtained by this method are shown in column 2 of Table IV.

It is useful to have a measure of the heat evolved by the slow oxidation of stored coal; and unpublished experiments are in progress to measure this heat. It has been found that if the heat generated is measured in terms of the volume of oxygen absorbed, the value is almost independent of the rank of the coal. The average value found to date is about 465 B.t.u. per cubic foot of oxygen absorbed, measured at normal temperature pressure, or 98 B.t.u. for the oxygen in a cubic foot of air. This is about 90 per cent of the heat which would be generated by complete combustion, as shown in column 6 of Table IV.

Agglomeration, friability and pulverizability are important characters of coals in relation to their use in furnaces, but they will not be discussed here.

## COAL ANALYSIS CHARTS AND SELECTED ANALYSES OF ALBERTA COALS

There are at present some thirty-three coal-producing areas in Alberta. The fifteen areas with the largest outputs in 1936 have been selected, and tabular data for the coals in these areas are given, to illustrate the different points discussed. The areas are listed in Table I and are indicated by reference numbers in the coal areas map of Alberta, Fig. 1.

Table I

Selected Coal Areas

| Area | Geological Horizon | Reference Number | Alberta Classification |
|---|---|---|---|
| Mountain Park: | | | |
| Higher volatile coals.. | Kootenay | K 3, A | Bituminous[4] |
| Lower volatile coals... | Kootenay | K 3, B | Bituminous[2] |
| Nordegg............... | Kootenay | K 4 | Bituminous[2] |
| Cascade: | | | |
| Higher volatile coals.. | Kootenay | K 7, A | Bituminous[2] |
| Lower volatile coals... | Kootenay | K 7, B | Bituminous[1] |
| Crowsnest............. | Kootenay | K 10 | Bituminous[3] |
| Prairie Creek........... | Belly River | B 2 | Subbituminous[5] |
| Coalspur............... | Belly River | B 3 | Subbituminous[6] |
| Saunders............... | Belly River | B 4 | Subbituminous[6] |
| Lethbridge............. | Belly River | B 9 | Domestic[6] |
| Pembina............... | Edmonton | E 1 | Domestic[7] |
| Edmonton.............. | Edmonton | E 2 | Domestic[7] |
| Camrose............... | Edmonton | E 4 | Domestic[8] |
| Castor.................. | Edmonton | E 5 | Domestic[8] |
| Carbon................. | Edmonton | E 8 | Domestic[7] |
| Sheerness.............. | Edmonton | E 9 | Domestic[8] |
| Drumheller............ | Edmonton | E 10 | Domestic[7] |

The areas are arranged geographically in each geological horizon; that is roughly in a northwest to southeast direction. The order has no other significance. The way in which these coals probably would be classified according to the A.S.T.M. specifications is indicated by the reference numbers and the following key:—

(1)Semianthracite; (2)Low volatile bituminous coal; (3)Medium volatile bituminous coal; (4)High volatile A bituminous coal; (5)High volatile B bituminous coal; (6)High volatile C bituminous coal; (7)Subbituminous B coal; (8)Subbituminous C coal.

Some of the coals, however, lie across a boundary line and might be classified in two classes.

The analyses of coals from an area will vary from mine to mine, but even from the same mine may vary notably in ash and moisture according to local conditions and degree of cleaning. It is therefore very difficult to state a typical analysis for an area, and such analysis, if published, is apt to be taken more seriously than is warranted. Even if a typical analysis of the clean, dry coal were stated, it would not be possible to calculate therefrom the analysis for any particular ash and moisture because of uncertainty with regard to mineral impurities, as discussed above. It is possible, however, to construct charts[8] showing the way the different constituents in a coal vary with the ash percentage and the moisture percentage. If the latter factor is not represented on the chart, correction for moisture can be made by simple calculations, as will be shown later.

A set of four charts for one (subbituminous) coal are shown in Fig. 2. A dotted arrow in each chart illustrates its use for ascertaining the analysis of a sample with 8.5 per cent ash and 5 per cent moisture—or with 9 per cent ash in the dry coal. Chart I gives the proximate analysis; the volatile matter corresponding to 8.5 per cent ash and 5 per cent moisture is shown to be 38.4 per cent and the fixed carbon is found to be 48.1 per cent by subtracting the sum of the other percentages from 100. Chart II gives the gross calorific value and Chart III gives the ultimate analysis of the dry coal. If it were desired to determine the ultimate analysis of a coal with 8.5 per cent ash and 5 per cent moisture, it would be necessary first to calculate

Table II

Data for Construction of Coal Charts

All values on the dry coal basis

| Area | Percentage | | | Percentage | | | | | C.V. | F |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ash | V.M. | F.R. | C | H | S | N | O | B.t.u. per lb. | |
| K 3, A | 0 | 33.3 | 2.0 | 87.8 | 5.5 | 0.3 | 1.4 | 5.0 | 15,660 | 1.10 |
| K 3, A | 20 | 24.2 | 2.3 | 69.8 | 4.0 | 0.5 | 0.9 | 4.8 | 12,200 | |
| K 3, B | 0 | 24.2 | 3.1 | 89.9 | 4.9 | 0.3 | 1.4 | 3.5 | 15,830 | 1.13 |
| K 3, B | 20 | 19.3 | 3.1 | 71.0 | 3.8 | 0.3 | 0.9 | 4.0 | 12,250 | |
| K 4 | 0 | 18.1 | 4.5 | 90.6 | 4.7 | 0.5 | 1.4 | 2.8 | 15,930 | 1.13 |
| K 4 | 20 | 14.5 | 4.5 | 71.6 | 3.6 | 0.4 | 0.9 | 3.5 | 12,330 | |
| K 7, A | 0 | 15.0 | 5.7 | 90.6 | 4.3 | 0.8 | 1.6 | 2.7 | 15,690 | 1.09 |
| K 7, A | 20 | 13.3 | 5.0 | 71.8 | 3.4 | 0.8 | 1.2 | 2.8 | 12,280 | |
| K 7, B | 0 | 10 7 | 8.3 | 92.4 | 4.0 | 0.7 | 1.3 | 1.6 | 15,770 | 1.13 |
| K 7, B | 20 | 10.4 | 6.7 | 72.1 | 3.2 | 1.2 | 0.9 | 2.6 | 12,200 | |
| K 10[1] | 0 | 33.3 | 2.0 | 87.7 | 5.4 | 0.5 | 1.4 | 5.0 | 15,640 | 1.14 |
| K 10[1] | 20 | 22.8 | 2.5 | 69.2 | 3.9 | 0.5 | 1.1 | 5.3 | 12,080 | |
| B 2 | 0 | 41.7 | 1.4 | 82.3 | 5.7 | 0.3 | 1.5 | 10.2 | 14,820 | 1.25 |
| B 2 | 20 | 34.8 | 1.3 | 64.0 | 4.0 | 0.3 | 1.3 | 10.4 | 11,100 | |
| B 3 | 0 | 41.7 | 1.4 | 79.6 | 5.1 | 0.2 | 0.9 | 14.2 | 13,910 | 1.26 |
| B 3 | 20 | 33.3 | 1.4 | 61.1 | 3.6 | 0.1 | 0.7 | 14.3 | 10,400 | |
| B 4 | 0 | 40.8 | 1.45 | 80.2 | 5.3 | 0.3 | 1.2 | 13.0 | 14,160 | 1.33 |
| B 4 | 20 | 30.2 | 1.65 | 63.0 | 3.5 | 0.4 | 0.9 | 12.2 | 10,380 | |
| B 9 | 0 | 40.8 | 1.45 | 79.2 | 5.3 | 0.5 | 1.8 | 13.2 | 13,940 | 1.11 |
| B 9 | 20 | 37.2 | 1.15 | 62.2 | 4.3 | 0.8 | 1.7 | 11.0 | 10,850 | |
| E 1[2] | 0 | 37.0 | 1.70 | 76.5 | 4.5 | 0.3 | 1.1 | 17.6 | 12,900 | 1.10 |
| E 1[2] | 20 | 30.8 | 1.60 | 61.2 | 3.6 | 0.3 | 0.9 | 14.0 | 10,050 | |
| E 2 | 0 | 39.2 | 1.55 | 76.1 | 4.8 | 0.3 | 1.5 | 17.3 | 13,000 | 1.11 |
| E 2 | 20 | 36.3 | 1.20 | 58.6 | 4.1 | 0.4 | 1.1 | 15.8 | 10,100 | |
| E 4[3] | 0 | 42.5 | 1.35 | | | | | | 12,800 | 1.05 |
| E 4[3] | 20 | 34.8 | 1.30 | | | | | | 10,100 | |
| E 4[3] | 6 | | | 70.5 | 4.7 | 0.4 | 1.4 | 17.0 | | |
| E 5[3] | 0 | 43.5 | 1.30 | | | | | | 12,600 | 1.05 |
| E 5[3] | 20 | 36.3 | 1.20 | | | | | | 9,950 | |
| E 5[3] | 8 | | | 67.5 | 4.6 | 0.5 | 1.3 | 18.1 | | |
| E 8 | 0 | 38.4 | 1.60 | 76.7 | 5.1 | 0.4 | 1.3 | 16.5 | 13,350 | 1.07 |
| E 8 | 20 | 33.3 | 1.40 | 61.6 | 3.9 | 0.4 | 1.1 | 13.0 | 10,500 | |
| E 9 | 0 | 43.5 | 1.30 | 73.7 | 4.9 | 0.4 | 1.5 | 19.5 | 12,550 | 1.05 |
| E 9 | 20 | 35.5 | 1.25 | 57.6 | 4.0 | 0.8 | 1.2 | 16.4 | 9,930 | |
| E 10 | 0 | 40.0 | 1.50 | 76.1 | 5.0 | 0 5 | 1.6 | 16 8 | 13,240 | 1.14 |
| E 10 | 20 | 34.8 | 1.30 | 59.8 | 4.0 | 0.5 | 1.3 | 14.4 | 10,210 | |

Both volatile matter (V.M.) and fuel ratio (F.R.) are given for interest, although these are interrelated. The fuel ratio is the fixed carbon divided by the volatile matter. The carbon, hydrogen, sulphur, nitrogen and oxygen are indicated by their chemical symbols, C, H, S, N, and O. The symbol F is used for the mineral matter-to-ash ratio. The data given are for fresh coal, and are not applicable to weathered coals.

(1)In this area (K 10) the values are representative of the coals from the centre of the area, where the larger mines are located. The coals from some small mines in outlying districts are notably different.

(2)The values cited for E 1 are based on analyses from a mine which is now shut down, they are not representative of the whole area.

(3)In these areas (E 4 and E 5) sufficient data are not available for plotting the ultimate analysis charts, but values at one ash content are given.

the corresponding ash in the dry coal; thus $\left(8.5. \times \frac{100}{100-5}\right)$ gives 8.95 per cent ash. The ultimate analysis of the dry coal with that ash could then be read off from the chart. This dry coal analysis would then be adjusted to the 5 per cent moisture basis by simple calculation in the case of carbon, sulphur and nitrogen:—thus,

$$\text{Carbon per cent (dry)} \times \frac{100-5}{100} = \text{carbon per cent (moist).}$$

In the case of hydrogen and oxygen a further adjustment is needed to include the hydrogen and oxygen in the 5 per cent of water:—thus

$$\left(\text{hydrogen per cent dry} \times \frac{100-5}{100}\right) + \frac{2.016 \times 5}{18.016} = \text{hydrogen per cent (moist);}$$

the corresponding addition for oxygen is $\frac{16.0}{18.016}$ times the moisture per cent. It is not proposed to discuss Chart IV; the values given refer to tons of 2,000 pounds, and to the solid coal as it occurs in the seam.

Charts of the type shown, when used for fresh coal from a single mine, are generally accurate enough for all ordinary use. Thus if a coal seller specifies the ash and moisture for the coal he tenders, the consumer can obtain from the charts the complete analysis of the coal he is to receive; this system allows for ready adjustment by both parties according as to whether cleaned coal, run-of-mine, or slack coal is to be supplied.

The coal charts are less accurate for individual coals when drawn to represent the average coal of a district or area, but they can be used for general discussions as in this paper.

Data are given in Table II from which charts could be drawn to represent the average coal for each of the seventeen areas, or sub-areas, listed. Straight lines may be drawn in such charts from the values given at 0 per cent ash to those at 20 per cent. Considerable experience with Alberta coals has shown that the values for all the constituents given, when plotted against ash, lie in a straight line within the limits of probable errors.

## DECOMPOSITION OF COAL WITH HEAT

### Decomposition and Softening Temperatures

When a coal is heated, in the absence of air, it soon loses moisture and may slowly lose carbon dioxide and other gases. This slow decomposition increases with temperature, and finally a temperature is reached at which decomposition is quite rapid, with the evolution of gas and tar. Some coals, called coking coals, soften or become plastic when heated, finally hardening with further heat into the hard, cellular material called coke. It is not easy to specify any determinable temperatures as decomposition and softening temperatures, but a method[3] was developed in the R.C.A. laboratories and values determined for a number of coking, or of near-coking, coals. Some average values thus obtained are shown in columns 3 and 4 of Table IV.

It has been suggested that a coal will coke readily if the softening temperature is distinctly below the decomposition temperature. However, a coking coal may be heated above the softening temperature without the formation of coke, if the heating is carried out so slowly that the fusible matter decomposes before it softens. The low rank coals, as a class, have a low decomposition temperature and do not coke.

### Volatile and Non-Volatile Fractions of Coal

When coal is heated strongly, as in the determination of volatile matter in the laboratory, volatile products of decomposition are driven off and a non-volatile coke or char is left behind in the crucible. The recorded loss in weight is for analytical purposes divided into two parts, moisture and volatile matter, whilst the weighed coke or char is taken as made up of ash and fixed carbon. The sum of the four percentages therefore must equal 100.

Low rank coals are characterized as being high-volatile coals. It is therefore important to consider the relative amounts of volatile and non-volatile fuel in such coals; as well as to consider the distribution of the total heat of the coal, and of the total volume of air required for combustion, between the volatiles and non-volatiles.

In the laboratory test for volatile matter a small sample of powdered coal is heated for seven minutes at 1,742 deg. F. (The lower rank coals have to receive a preliminary heating at a lower temperature to avoid mechanical loss of non-volatiles with the otherwise too rapid evolution of gases.) Since there is no reason why this temperature of 1,742 deg. F. should have any significance in boiler practice, its suitability for use in combustion studies was investigated experimentally by heating a series of five coals at three temperatures, 1,112 deg. F. 1,472 deg. F. and 1,742 deg. F. (600, 800 and 950 deg. C.), and subjecting the residues to ultimate and calorific analyses. Some of the results obtained are shown in Table III.

The yields of non-volatiles shown indicate that, on the average, the five coals lost 28 per cent at the lowest temperature, 7 per cent more to the next temperature, and only 2 per cent extra for the last stage; the losses of heat values in the volatiles show similar conditions. The ultimate analyses of the residues show that after heating to 1,742 deg. F. the aggregates of the elements hydrogen, sulphur, nitrogen and oxygen have been reduced to about 3 per cent, so that the fixed carbon left at that temperature is nearly pure carbon. It is therefore safe to assume that little further change would occur at the higher temperatures of the furnace, so that there is no serious objection to the use of 1,742 deg. F. in these studies; furthermore, the selection of this temperature makes possible the use of a large amount of available laboratory data.

Less comprehensive tests were made on some forty-one other coals; the results from all the tests showed that the heat of the non-volatile part of any coal could be calculated with considerable accuracy by multiplying the determined percentage of fixed carbon by 145.5. The

Table III

Decomposition of Coal With Heat

| Source of coal sample—Area | K 10 | B 3 | E 2 | E 10 | E 12 |
|---|---|---|---|---|---|
| Yield of non-volatiles—from dry coal | | | | | |
| Treated at 1,112 deg. F. (600 deg. C.) % | 76.8 | 73.3 | 71.1 | 70.2 | 69.1 |
| Treated at 1,472 deg. F. (800 deg. C.) % | 72.4 | 65.2 | 63.7 | 62.4 | 61.0 |
| Treated at 1,742 deg. F. (950 deg. C.) % | 70.6 | 61.6 | 62.1 | 60.8 | 60.0 |
| Heat of coal in non-volatiles | | | | | |
| At 1,112 deg. F. % | 71.5 | 74.0 | 77.3 | 74.5 | 71.4 |
| At 1,472 deg. F. % | 64.8 | 67.3 | 69.6 | 67.1 | 63.1 |
| At 1,742 deg. F. % | 63.0 | 61.1 | 66.2 | 64.8 | 61.4 |
| Percentage of H + S + N + O | | | | | |
| In original dry coal % | 11.8 | 18.7 | 22.5 | 22.2 | 20.6 |
| In residue at 1,112 deg. F. % | 7.0 | 9.8 | 10.0 | 12.0 | 9.7 |
| In residue at 1,472 deg. F. % | 4.5 | 3.9 | 3.6 | 6.1 | 3.7 |
| In residue at 1,742 deg. F. % | 2.9 | 2.9 | 3.0 | 3.4 | 2.5 |
| Combustion of non-volatiles (1,742 deg. F.) | | | | | |
| B.t.u. liberated per cu. ft. of oxygen required | 490 | 490 | 491 | 494 | 492 |

These values were obtained from single samples and are not area averages.

Area E 12 is Champion area.

The treatment, with only three exceptions, was seven minutes heating in a platinum crucible at the full heat for the treatment. The last three coals, however, for the highest treatment, were given a preliminary heat for five minutes at 1,472 deg F. followed by the full heat treatment for six minutes at 1,742 deg. F.

The percentage of heat in non-volatiles is based on the gross calorific value of the coal.

product shows the heat units (B.t.u.) available from the non-volatile residue from one pound of the coal. This makes it easy to calculate the distribution of calorific value between the volatile and non-volatile fractions of any coal.

The bottom set of figures in Table III show that in the combustion of the cokes or chars (made at 1,742 deg. F.) the heat liberated, when stated in B.t.u. per cubic foot of the oxygen required for the combustion, varied very little from the average value of 491. The volume of oxygen required was calculated from the ultimate analysis of each coke. This value of 491 B.t.u. per cubic foot of oxygen, taken with the calculated heat of the non-volatiles, makes it now possible to calculate the volume of air required to burn the non-volatiles in any coal. The total air requirements of the original coal can be calculated from its ultimate analysis, as shown later, so that the percentage distribution of the air for combustion between the volatiles and the non-volatiles can also be calculated. Some of these calculated values are shown in Tables IV and V.

The results are rather surprising, for example in the percentages of gross heat in the non-volatiles, shown in column 7 of Table IV, it can be seen that whilst the semi-anthracitic coal of area K 7, B has the highest value, some of the domestic coals have higher values than have some of the bituminous coals. The same is true even if the net calorific value is considered as in column 8. Quite similar results are found in the values for the percentages of total air required for non-volatiles, as shown in column 2 of Table V.

In Fig. 3 average analyses of coals from a number of Canadian coal districts or coal mines have been plotted. The values chosen for plotting this coal band are the fixed carbon percentages and gross calorific values in B.t.u. per pound, both on the moist coal basis. In the same chart are plotted lines drawn through calculated points where the percentage of the heat in the non-volatiles is 50 per cent, 55 per cent, and so on, respectively. It can be seen that the 65 per cent line, for example, lies along the lower end of the sloping limb of the band and then cuts across the nearly vertical limb. It is thus easy to see how it is that quite different coals may show the same percentage of non-volatile heat. Similar conditions could be charted for air requirement distribution.

TABLE IV

MISCELLANEOUS AND CALORIFIC DATA

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Coal with capacity moisture | |
| Area | Oxygen absorbed, pure dry coal, weight Per cent | Softening temperature of coal Deg. F. | Decomposition temperature of coal Deg. F. | Ignition temperature of coal Deg. F. | Calorific value per cu. ft. air required B.t.u. | Percentage of gross heat in non-volatiles | Per cent of net heat in non-volatiles | Reduction gross to net B.t.u. Per cent |
| K 3, A | 0.3 | 710 | 760 | 415 | 107.0 | 63.5 | 65.7 | 3.4 |
| K 3, B | 0.2 | 760 | 780 | 440 | 107.0 | 70.6 | 72.8 | 3.1 |
| K 4 | 0.3 | 785 | 790 | 435 | 107.0 | 75.6 | 77.9 | 2.9 |
| K 7, A | | | | 460 | 107.0 | 78.9 | 81.2 | 2.7 |
| K 7, B | | | | 470 | 106.0 | 82.7 | 84.8 | 2.5 |
| K 10 | 0.3 | 730 | 750 | | 107.0 | 64.5 | 66.7 | 3.3 |
| B 2 | 0.6 | | | | 108.5 | 58.0 | 60.5 | 4.1 |
| B 3 | 0.8 | | 630 | 345 | 109.0 | 62.5 | 65.2 | 4.2 |
| B 4 | 0.9 | | | 340 | 108.0 | 63.7 | 66.6 | 4.3 |
| B 9 | 0.9 | | | | 108.0 | 60.3 | 63.3 | 4 7 |
| E 1 | | | | 330 | 107.0 | 71.2 | 75.3 | 5.5 |
| E 2 | 1.4 | | | 325 | 109.0 | 66.3 | 70.9 | 6.4 |
| E 4 | | | | 325 | 107.5 | 65.2 | 70.2 | 7.0 |
| E 5 | | | | 325 | 108.5 | 64.8 | 69 7 | 7.0 |
| E 8 | 1.2 | | | 330 | 108.5 | 66.3 | 70 0 | 5.3 |
| E 9 | 1.3 | | | | 109.0 | 65.4 | 70.4 | 7.1 |
| E 10 | 1.2 | | | 330 | 109.0 | 65.5 | 69.4 | 5.6 |

Columns 2, 3, 4 and 5 give values obtained by specific methods described. The absolute values would change with method employed, but the relative values are significant.

Gas volumes are measured at Normal Temperature and Pressure (N.T.P.), that is at 32 deg. F. and 29.92 in. of mercury (0 deg. C. and 760 m.m.)

TABLE V

AIR REQUIREMENTS AND FLUE GAS DATA

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| | | | Pure dry coal | | | Pure coal with "capacity" moisture | | |
| Area | Per cent of total air required for non-volatiles | $CO_2$ in dry flue gases (theoretical) Per cent | Air required cu. ft. per lb. coal | Flue gas (wet) cu. ft. per lb. coal | Cu. ft. flue gas (wet) per gross therm | Flue gas (wet) cu. ft. per lb. coal | Cu. ft. flue gas (wet) per net therm | B.t.u. net, per cu. ft. wet flue gas |
| K 3, A | 66 0 | 18.65 | 145 | 150 | 970 | 148 | 1,006 | 99.5 |
| K 3, B | 73 2 | 18.80 | 146 | 151 | 967 | 149 | 999 | 100.1 |
| K 4 | 78.5 | 18.85 | 147 | 151 | 962 | 150 | 993 | 100.8 |
| K 7, A | 81.8 | 19 00 | 146 | 150 | 962 | 148 | 991 | 100.9 |
| K 7, B | 84.9 | 19.10 | 147 | 151 | 969 | 149 | 996 | 100.5 |
| K 10 | 67.1 | 18.70 | 144 | 149 | 967 | 137 | 1,001 | 99.9 |
| B 2 | 61.1 | 18.75 | 134 | 140 | 964 | 131 | 1,017 | 98.4 |
| B 3 | 66.2 | 19.20 | 125 | 131 | 961 | 121 | 1,019 | 98.2 |
| B 4 | 66.6 | 19.10 | 128 | 134 | 973 | 123 | 1,034 | 96.7 |
| B 9 | 63.1 | 18.85 | 128 | 134 | 973 | 122 | 1,041 | 96.1 |
| E 1 | 74.1 | 19.55 | 119 | 125 | 981 | 106 | 1,079 | 92.7 |
| E 2 | 70.1 | 19.35 | 118 | 125 | 969 | 100 | 1,094 | 91.4 |
| E 4 | 68.0 | 19.30 | 119 | 125 | 981 | 97 | 1,123 | 89.0 |
| E 5 | 68.2 | 19.35 | 116 | 122 | 976 | 96 | 1,115 | 89.7 |
| E 8 | 69.7 | 19.20 | 122 | 129 | 971 | 111 | 1,059 | 94.4 |
| E 9 | 69.2 | 19 45 | 115 | 121 | 970 | 94 | 1,113 | 89.8 |
| E 10 | 69.1 | 19.25 | 120 | 127 | 969 | 107 | 1,067 | 93.7 |

Gas volumes all measured at N.T.P., 32 deg. F. and 29.92 in. mercury.

Dry flue gas refers to flue gas as analyzed in the laboratory, i.e., with the steam condensed to water and therefore not occupying volume in the gas.

Wet flue gas refers to flue gas with steam as it leaves the furnace. When the volume is computed to N.T.P. the steam is assumed to remain uncondensed.

The above discussions consider distributions between the volatile and non-volatile portions of coal in simple form; in the furnace fire the conditions are more complicated. If air is passed up through a bed of hot fuel, the carbon dioxide produced at the bottom may higher up be partially reduced to carbon monoxide by the hot carbon. Some of the non-volatile fuel is thus converted to a volatile fuel which burns in the flames above the fuel bed. Similarly, if steam is blown into the ash pit this reacts with the hot carbon to form water gas, and again non-volatile fuel is converted into volatile fuel. These two reactions are probably more affected by the firing conditions than by the rank of the coal, but in any case they could not be evaluated and considered in the present discussions.

## COMBUSTION CALCULATIONS—AIR AND FLUE GAS VOLUMES

In the following calculations the atomic symbols $C$, $H$, $O$ and $S$ are each taken to represent the percentage of that element in the coal. Whole figure atomic weights have been taken for sake of simplicity, since the differences from the correct values are less than the probable errors of analysis. Thus carbon is taken as 12, hydrogen 1, oxygen 16 and sulphur 32. The nitrogen in the coal can be neglected as in many cases can also be the sulphur. It is assumed that air contains 21 per cent of oxygen and 79 per cent of nitrogen (N). One pound-molecule of any gas occupies 359.0 cu. ft. at Normal Temperature and Pressure (N.T.P.), that is at 32 deg. F. and 29.92 in. of mercury (0 deg. C. and 760 m.m.); thus, for example, 44 lb. of carbon dioxide (12 + 32 lb.) occupies 359 cu. ft. at N.T.P.

One hundred pounds of coal contains $\frac{C}{12}$ lb.-atoms of carbon, $\frac{H}{1}$ of hydrogen, $\frac{O}{16}$ of oxygen, and so on. This weight would require for its combustion $\left(\frac{C}{12}+\frac{H}{4}+\frac{S}{32}-\frac{O}{32}\right)$ lb.-molecules of oxygen, and this oxygen would be accompanied, in the air for combustion, by 79/21 times this volume of nitrogen, if the theoretical or ideal amount of air only were supplied. The products of combustion would be, in lb.-molecules, $C/12$ carbon dioxide, $H/2$ steam and $\left(\frac{C}{12}+\frac{H}{4}+\frac{S}{32}-\frac{O}{32}\right)$ 79/21 nitrogen. In dry flue gas (as analyzed) the steam is condensed to water (of negligible volume); whilst in wet flue gas it is considered present as steam even though cooled to 32 deg. F.

The equations involved can be simplified to show gas volumes in cubic feet at N.T.P. per pound of coal, as follows:

$$\text{Air required} = \frac{359}{400}\left(\frac{C}{3}+H-\frac{O-S}{8}\right)\frac{100}{21} \quad \text{(III)}$$

Since the term $\left(\frac{C}{3}+H-\frac{O-S}{8}\right)$ occurs in nearly every equation it has been replaced by the letter $Z$ for sake of brevity.

$$\text{Carbon dioxide produced} = \frac{359}{400}\times\frac{C}{3} \quad \text{(IV)}$$

$$\text{Dry flue gas} = \frac{359}{400}\left(\frac{C}{3}+\frac{79\,Z}{21}\right) \quad \text{(V)}$$

$$\text{Wet flue gas} = \frac{359}{400}\left(\frac{C}{3}+2H+\frac{79\,Z}{21}\right) \quad \text{(VI)}$$

$$\text{Per cent } CO_2 \text{ in dry flue gas} = \frac{100\,C/3}{C/3+79/21\,Z} \quad \text{(VII)}$$

If instead of the theoretical or ideal air only being supplied for combustion, $X$ per cent of excess air is supplied, then:—

$$\text{Air supplied} = \frac{359}{400}\times\frac{100+X}{21}Z \quad \text{(VIII)}$$

$$\text{Dry flue gas} = \frac{359}{400}\left(\frac{C}{3}+\frac{79+X}{21}Z\right) \quad \text{(IX)}$$

$$\text{Wet flue gas} = \frac{359}{400}\left(\frac{C}{3}+2H+\frac{79+X}{21}Z\right) \quad \text{(X)}$$

Per cent $CO_2$ in dry flue gas

$$= \frac{100\,C/3}{\frac{C}{3}+\frac{79+X}{21}Z} \quad \text{(XI)}$$

$$\frac{\text{Per cent } CO_2 \text{ with ideal air}}{\text{Per cent } CO_2 \text{ with } X\% \text{ excess air}} = \frac{\frac{C}{3}+\frac{79+X}{21}Z}{C/3+79/21\,Z} \quad \text{(XII)}$$

Exception might be taken to volumes of flue gases being stated at N.T.P., particularly when it involves the assumption of the presence of steam at that low temperature. However, Normal Temperature and Pressure is well known, and it is easy to calculate the volumes given from this base to any other temperature and pressure. Thus, if $V_{ntp}$ is the volume at N.T.P. and $V_{tp}$ the volume at any other temperature and pressure $t$ and $p$, where the temperatures are in degrees Fahrenheit and the pressures in inches of mercury, then:—

$$V_{tp} = V_{ntp}\left(1+\frac{t-32}{491.56}\right)\left(\frac{29.92}{p}\right) \quad \text{(XIII)}$$

Values were worked out for the ratio shown in equation XII for three coals of widely varying proportions of carbon, hydrogen and oxygen. It was found that if $X$ = per cent of excess air, $B$ = per cent of $CO_2$ in actual flue gas and $C$ = per cent of $CO_2$ in theoretical flue gas, the following equation was correct, within the limits of experimental errors of analysis, for all three coals regardless of their different compositions:—

$$X = \frac{100}{1.02}\left(\frac{C}{B}-1\right) \quad \text{(XIV)}$$

The alignment chart, based on equation XIV, shown in Fig. 4 was kindly prepared by Dr. A. J. Cook, Associate Professor of Mathematics at the University of Alberta. In this diagram the dotted line shows, as an example of its use, that if the actual flue gas from a furnace is found to contain 13 per cent carbon dioxide (line $B$), when a coal is being burned which would give 19 per cent carbon dioxide (line $C$), with perfect combustion when the theoretical amount of air is employed, then the excess air actually supplied in the furnace is 45 per cent (line $A$).

Values of carbon dioxide percentages in dry flue gas, with theoretical air, are shown in Table V, column 3, whilst air requirements and flue gas volumes, per pound of pure dry and of pure moist coal, are shown in columns 4, 5 and 7. The moist coal is coal with its capacity moisture.

The values for carbon dioxide percentages in the ideal, dry, flue gas (column 3) are rather surprising. In the high rank coals this percentage falls with decreasing rank of coal, but it can be seen that, instead of continuing to fall with the rank, a minimum is reached with the high volatile bituminous coals and that the domestic coals give higher percentages even than the semi-anthracitic coals. This variation in percentages is shown graphically in Fig. 5. A number of Canadian coal analyses are here plotted on the Seyler chart basis,[10] and calculated lines for equal carbon dioxide percentages are drawn on the chart. It can be seen that the minimum carbon dioxide is found near the bend of the coal band, and that the percentages of carbon dioxide increase in either direction along the limbs.

## FLAME TEMPERATURES

If no heat were lost by radiation or otherwise when a fuel is burned, the sensible heat of the flue gases produced should equal the heat of combustion of the fuel. Therefore, if the volume of flue gases were calculated and their mean specific heat known, and if suitable units were used throughout, a flame temperature might be calculated by dividing the product of the volume of the gases and their specific heat into the available amount of heat. This is the problem reduced to its simplest terms; actually an estimation of flame temperature is a complicated problem. Thus, radiation can not be neglected, particularly in a boiler furnace where it is planned to radiate the maximum heat possible to the water tubes. Moreover, combustion can not be complete at high temperatures; this is usually stated in reverse order by saying that the products of combustion, carbon dioxide and steam, dissociate at high temperatures into carbon monoxide, hydrogen and oxygen. The extent of dissociation, or loss of combustibles from the high temperature zone of the fire, depends on the temperature and on the concentrations of all the gases involved in the reactions. It is therefore doubly dependent on the amount of excess air employed. The extent of the dissociation factor may be guessed at from the statement that at atmospheric pressure pure carbon dioxide dissociates 0.2 per cent at 2,550 deg. F., 1.5 per cent at 3,090 deg. F. and 6.0 per cent at 3,630 deg. F. The corresponding values for pure steam are 0.08, 0.5 and 1.9 per cent. It is not suggested that the dissociation factor involves a permanent loss of heat, since the carbon monoxide and hydrogen may continue burning, to completion, as the gases cool. A further complication in flame temperature calculations is the fact that the specific heats of the different gases included in the flue gases vary with the temperature, and that the relation is not a simple one. Finally, and particularly with long-flame coals, combustion is not something which happens and is completed in, or just over, the fire bed; so that any theoretical calculations are liable to be in error. Nevertheless, it is suggested that the calculated flame temperatures of a series of coals may give a good insight into their comparative values as furnace fuels, if the calculations are all based on the same assumptions. Flame temperatures are also of value when taken in conjunction with the ash fusion temperatures of the same coals. Seyler[12] in his Fuel Chart relates the flame temperature to the net calorific value of the coal as fired. This relation, copied from his chart, is shown in Fig. 6. Thus a coal with a net calorific value of 14,000 B.t.u. might give a flame temperature of 3,700 deg. F., one of 11,000 B.t.u. a temperature of 3,580 deg. F., and one of 6,000 B.t.u. a temperature of 3,200 deg. F. Seyler does not show how his flame temperatures were calculated, nor what allowances, if any, were made for radiation and dissociation losses; but it may be safely assumed that the use of this graph, with the net calorific values of a series of coals as fired, will give reasonably comparative flame temperatures when the coals are burned with the ideal volume of air. Seyler gives some minor adjustments which should be made, and also equations for correcting the flame temperatures for different amounts of excess air, and for preheat in the air, but for these the original paper must be consulted.

It is obvious that the flame temperature goes down with the rank of the coal, and that it is reduced by the presence of water in the coal and by the use of excess air for combustion; it can be raised by preheating the air. The flame temperature is extremely important in its influence on the transmission of heat from the furnace to the boiler tubes by means of radiation. According to the Stefan-Boltzmann law radiation is proportional to the difference between the fourth power of the absolute temperature of the radiating body and the fourth power of the absolute temperature of the receiving body. Thus if the heat absorbing surfaces of the boiler had a mean temperature of 500 deg. F., raising the temperature of the furnace flame from 2,500 deg. F. to 3,055 deg. F. would approximately double the transmission of heat by radiation.

## ASH FUSION TEMPERATURES

In the A.S.T.M. specifications[2] for the determination of ash fusibility, small cones of the ash, of standardized size and shape, are heated with a definite rate of rise in temperature, in a mildly reducing atmosphere. The cones are carefully watched and the three temperatures noted at which specific changes occur. These are:—(1) The Initial Deformation Temperature, the temperature at which the first rounding or bending of the apex of the cone takes place. Such bending must not be confused with a shrinking or warping of the cone. (2) The Softening Temperature, the temperature at which the cone has fused down to a spherical lump. (3) The Fluid Temperature, the temperature at which the cone has spread out over the base in a flat layer.

The softening temperature is the temperature normally indicated in references to ash fusion temperatures.

In the laboratories of the R.C.A. a modified method has been developed[9] and is frequently employed. In this method the above specifications with respect to cones, rate of heating, and atmosphere, are followed exactly; but instead of only heating 3 or 4 cones at once and watching closely their behaviour, a batch of 20 or more different cones are simultaneously heated to some prearranged temperature, and then rapidly cooled and withdrawn from the furnace. Similar batches are likewise heated to other temperatures, until for each ash a series is obtained of cones heated to temperatures at 45 deg. F. (25 deg. C.) intervals. The

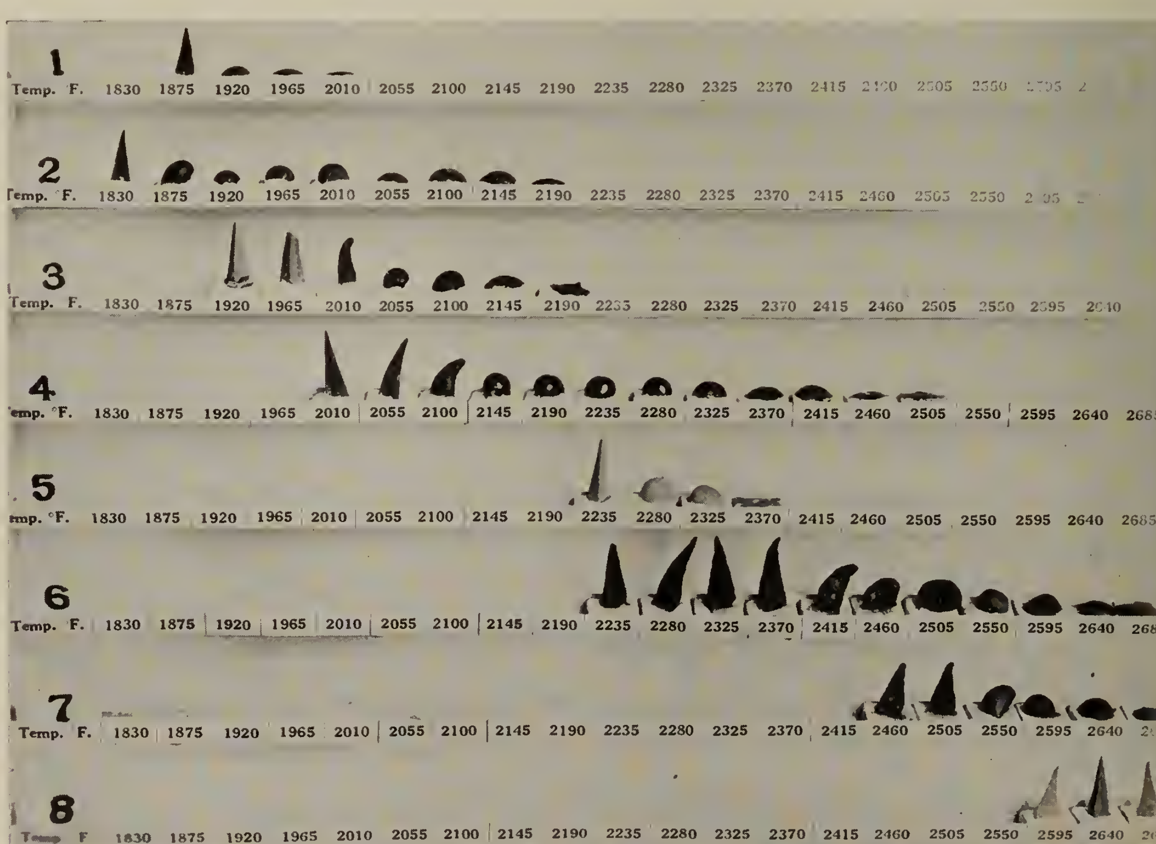


Fig. 7—Ash Fusion Cones.

series can then be arranged in order and examined at leisure for the fusion characteristics of the ash.

Figure 7 shows eight such series of ash cones. In series 4 initial deformation is just visible at 2,055 deg., the softening temperature is shown at 2,145 deg. and the fluid temperature at 2,460 deg. F. In some cases the temperatures must be estimated, as in series 1, for example, the initial deformation and the fluid temperature both occur between 1,875 deg. and 1,920 deg. It might be pointed out that in the regular method it is not easy to control all the conditions simultaneously, and also to identify exactly all three temperatures for 3 or 4 cones in an intensely hot furnace. The R.C.A. method has the advantage of giving a permanent picture of the ash character.

In the figure, series 1 and 2 show ashes with low fusion temperatures, but in series 1 the complete range from initial deformation to fluid temperature is not more than 90 deg. whilst in 2 it is about 360 deg. In series 3 and 4, and in 5 and 6, similar contrasts of short and long ranges of softening and flowing are shown for higher fusion temperature ashes. Series 8 shows an ash which only just reached the initial deformation at the highest temperature tested, 2,685 deg. F. In series 3 there is a marked change in colour at the temperature of initial deformation. Series 8 also shows a colour change. Series 6 is characterized by swelling of the ash cone when heated—all the cones shown were the same size when made.

It is not easy to correlate with furnace practice laboratory data obtained with small ash cones. It would seem probable, however, that ash 1 of the figure would give little trouble in a stoker furnace because it would melt completely and run through the grates; ash 8 should give little trouble because it would not clinker except in a very hot fire. Ashes 4 and 6 would be more likely to give trouble on account of the probability of their reaching the pasty stage and yet not reaching the fluid stage. Ash 5 could probably be handled easily either in a fairly cool fire, or in a hot fire. Similar considerations would affect the use of the coals, corresponding to these ashes, in powdered coal equipment.

The low rank coals of Alberta have, in general, lower ash-fusion temperatures than the high rank coals of the province; this can not be a definite characteristic of all low rank coals. It should be noted, however, that a coal with a low ash-fusion temperature and low flame temperature may give less trouble due to clinker than coal with a medium ash-fusion temperature and a high flame temperature.

The ash of plants is comparatively fusible; so that it is to be expected that where such ash is little mixed with other mineral matter, as in a low ash coal, this ash also will be fusible. The ash of a cleaned coal is commonly more fusible than the ash of the raw coal, although the reverse is sometimes the case. The ash from separate lumps of coal from the same mine may sometimes show marked differences in fusion character; but nevertheless there is commonly enough uniformity in the mine run of ash, for coal from one mine, or even district, to be known to have a high fusion ash and coal from another mine or district to be known to have a low fusion ash. Blending two coals may have little influence on their ash fusibility, or it may produce an ash more fusible than either ash alone.

## GENERAL DISCUSSIONS AND CONCLUSIONS

The Alberta coals discussed, and for which values are given in the tables, cover a very wide range, although this is not quite as wide as it could be if all Alberta coals were included. The coals listed are all of cretaceous age (post-carboniferous), but are representative of three geological horizons. They rank as follows:—from semi-anthracite to (or nearly to) lignite, in the ordinary use of these terms: from semi-anthracite to sub-bituminous C coal, in the A.S.T.M. classifications; and from semi-anthracitic species to ortho-sub-lignitious, in Seyler's classification.

The ranges of variations in the analytical and combustion data of Tables II, IV and V are given in Table VI, with a few supplementary ranges. The values given in the actual range column are, whenever possible, the limit value of the high rank coals followed by the limit value of the low rank coals. In the percentage range column the maximum value of the actual range is in each case taken as 100.

The first eight items of analytical data in the table confirm the claim as to the wide range in character of the coals; this range is particularly shown by items 7 and 8. Study of the combustion values show a more varied picture. Items 9-12 have wide ranges, but this merely indicates that, just as the higher rank coals have higher heat values than the low rank coals, so also they require more air per pound for their combustion and produce more flue gas per pound of coal burned. Item 13 shows that there is a quite narrow range in the carbon dioxide percentages with ideal air, and, as already pointed out, this percentage does not vary regularly with the rank of the coal. Items 14-16 show very narrow ranges; there is remarkably little variation in the heats of combustion, throughout the whole range of these coals, if these heats are expressed either as gross or net B.t.u. per cubic foot of air required, or are expressed as gross B.t.u. per cubic foot of flue gas produced from the dry coal. In fact it might be concluded that there was little difference between the combustion of high and low rank coals, except that more pounds of the latter must be fired.

TABLE VI

ANALYTICAL AND COMBUSTION RANGES

| | Actual range | Percentage range | Reference* |
|---|---|---|---|
| Analytical values for pure, dry coal | | | |
| 1. Carbon........per cent | 92.4–73.7 | 100–80 | II–5 |
| 2. Hydrogen........per cent | 4.0– 5.7 | 70–100 | II–6 |
| 3. Oxygen........per cent | 1.6–19.5 | 8–100 | II–9 |
| 4. Fixed carbon........per cent | 89.3–56.5 | 100–63 | |
| 5. Gross calorific value........B.t.u. | 15,930–12,550 | 100–79 | II–10 |
| 6. Net calorific value........B.t.u | 15,490–12,090 | 100–78 | |
| Analytical values for pure moist coal (capacity moisture) | | | |
| 7. Capacity moisture........per cent | 1.5–27.3 | 5–100 | |
| 8. Net calorific value........B.t.u. | 15,240–8,500 | 100–56 | |
| Combustion values | | | |
| 9. Air required, per lb. pure, dry coal..cu. ft. | 147–115 | 100–78 | V–4 |
| 10. Air required, per lb. pure, moist coal. cu. ft. | 145– 83 | 100–57 | |
| 11. Flue gases (wet) per lb. pure, dry coal........cu. ft. | 151–121 | 100–80 | V–5 |
| 12. Flue gases (wet) per lb. pure, moist coal........cu. ft. | 150– 94 | 100–63 | V–7 |
| 13. Carbon dioxide in dry flue gases (ideal air)........per cent | 18.65–19.55 | 95–100 | V–3 |
| 14. Heat available per cu. ft. air required ........gross B.t.u. | 106–109 | 97–100 | IV–6 |
| 15. Heat available per cu. ft. air required........net B.t.u. | 103–106 | 97–100 | |
| 16. Heat available per cu. ft. flue gas from dry coal........gross B.t.u. | 104–102 | 100–98 | |
| 17. Heat available per cu. ft. flue gas from moist coal........net B.t.u. | 101– 89 | 100–88 | V–9 |
| Heat decomposition values | | | |
| 18. Heat of non-volatiles as per cent of total gross heat of coal........ | 82.7–58.0 | 100–70 | IV–7 |
| 19. Heat of non-volatiles as per cent of total net heat of moist coal........ | 84.8–60.5 | 100–71 | IV–8 |
| 20. Air for non-volatiles as per cent of total air required for coal........ | 84.9–61.1 | 100–72 | V–2 |

*The references are to the tables and columns from which the values have been taken.

The same number of cubic feet of air must be supplied for, and (from item 16) the same number of cubic feet of flue gas would be produced by, the generation of one therm of heat with any coal. It would therefore appear that the same furnace volume would be required regardless of the rank of the coal to be burned. Study of items 18-20 would not add much to change the above conclusions. They show that there is a notable range in the distribution of heat production and air requirements between the volatile and non-volatile fractions of the coals; but from Tables IV and V it can be seen that, although in every case the semi-anthracite has the highest values for the non-volatiles, there is little relation between distribution and rank with the bituminous and lower rank coals.

One combustion value was omitted above, item 17, the net B.t.u. available per cubic foot of flue gas from the combustion of coal with capacity moisture; this has a 12 per cent range. A study of Table V, column 9, shows that these values vary little with the high rank coals, but with the lower rank coals decrease with the rank of the coal. This value, Seyler's calorific intensity,[12] classifies the lower rank coals in approximately the same order as the A.S.T.M. classification. It is thus evident that, when net heat and the moisture in the coal as fired are given due consideration, even if other things were equal, a larger furnace volume would be required for the lower rank coals.

Other factors, however, also must be considered, factors which can not be stated numerically. It has been pointed out earlier that net calorific values fall rapidly with rank, that flame temperature falls with net calorific value, and that transmission of heat by radiation falls with the flame temperature; less heat will therefore be transmitted by radiation from a low rank coal and greater heating surface must be provided in consequence. A high preheat would raise the flame temperature, but this possibility may be restricted by ash fusibility. Careful avoidance of unnecessary excess air will also raise the flame temperature. In a powdered coal plant the use of heated air in the pulverizers and the consequent drying of the coal will also tend to raise the flame temperature.

Low rank coals are more easily oxidized, and have lower ignition temperatures than the higher rank coals, so that it is easier to burn the coal and there is less need for excess air. On the other hand the decomposition temperature is lower with low rank coals, so that volatile matter will be given off more rapidly and at a lower temperature than with high rank coals and there may be some risk of such volatile matter escaping unburned.

Data and an alignment chart have been provided to permit the estimation from a flue gas analysis of the excess air supplied to the furnace. These were prepared on the assumption that no unburned gases were present. If the percentage of excess air is reduced too much, unburned gases will result; increasing the excess air, on the contrary, increases the loss of sensible heat in the flue gases. Full flue gas analyses and flue temperature measurements make it possible to ascertain the optimum conditions for any coal.

It has already been pointed out that the heat generated per cubic foot of air supplied is remarkably constant, and is almost independent of the coal; in other words the air supplied and steam generated are very closely related and are independent of the quality of coal burned. This is, of course, the basic fact in the control of a steam plant. An air flow meter and a steam flow meter can be set to register on the same recorder chart, and be so adjusted that the two pens will record on the same line with optimum conditions of firing and air supply. The maintenance of matched readings by these meters then ensures the continuation of optimum conditions.

This paper is limited in its scope and falls far short of adequate treatment even of the subjects considered; it is hoped nevertheless that it may prove of some value along the lines of its stated objective.

The writer wishes to acknowledge gratefully the valuable assistance of his colleagues, Mr. W. A. Lang and Mr. K. C. Gilbart, in the investigations involved as well as in the preparation of this paper and its charts.

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# The Burning of Low Rank Alberta Coals

## The Steam Generating Plant

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

**SUMMARY.—This paper deals with the development in Alberta and Saskatchewan during the past decade of steam generating plants equipped for burning low-rank Alberta coals; notes on these plants and their equipment are given, with some performance data and suggestions as to trends of design.**

The World Power Conference of 1936 provided an opportunity for the publication of material dealing with the developments which have taken place in connection with the generation of electric energy, constituting the first comprehensive survey in regard to plant, equipment, performance and trends in design since the Berlin conference of 1930. This material yields a fair picture of the "state of the art" at this time. With the celebration by The Engineering Institute of its Semicentennial it seems fitting that local plant and methods should be reviewed and that possible applications of these new developments in the broader field to Canadian stations receive consideration.

### Power

Discussion will be limited to plant in which power is generated for public use. Published statistics[1] show that, at the end of 1934, the installed capacity of hydraulic stations in Alberta and Saskatchewan was 71,590 kva., an increase of 38,070 kva. over 1927. The capacity of fuel stations was 166,959 kva., an increase of 35,000 kva. for the same period. Consumption of electricity for domestic use was 65,284,000 kw.h. in 1934. The average annual domestic use was 520 kw.h. in Alberta and 785 in Saskatchewan, at a cost of 4.99 and 5.81 cents per kilowatt hour respectively. Revenue of hydraulic stations in 1934 was $1,687,310 and of fuel stations $5,623,724.

Electric Energy Generated—Kw.h.

| | Alberta | Saskatchewan |
|---|---|---|
| *Monthly Reports* | | |
| Hydraulic stations—1935 | 144,593,050 | |
| 1936 | 123,895,940 | |
| Fuel stations—1935 | 60,862,514 | 136,804,926 |
| 1936 | 90,689,979 | 143,228,409 |
| *Annual Reports* | | |
| Central electric stations, 1935 | | |
| Hydraulic | 145,063,286 | |
| Fuel | 62,990,889 | 138,479,026 |

The trend in recent years has been to consolidate power generation in a small number of relatively large plants, both fuel and hydraulic, and to operate as an interconnected system, fuel plants operating on base load during low water periods in the winter months, and as standby only during the balance of the year. Other fuel plants are on a standby basis throughout the year. Interconnected lines extend westward to the British Columbia boundary. In certain cases these arrangements for interconnection have been interrupted and in others, fuel plants have been required to provide pumping service for domestic water supply throughout the year. In general, interconnection of plant has resulted from economic studies. However, certain plants have retained the interconnection for the purpose of mutual assistance in case of trouble and to avoid interruption of the service.

Note:—References to the bibliography at the end of the paper are indicated by superscript numbers, thus [1].

A low head (14-ft.) 10,000-kw. pumping unit, operated from a hydraulic power station for irrigation in a dry area, is a recent development. The experiment is interesting in that the intention is not to encourage the intensive farming methods characteristic of irrigation projects, but rather to serve areas which are above the main irrigation ditch, with a view to growing regular prairie crops on land which would otherwise be too dry for this purpose. Such devices have advantages as load builders. They may be operated as off-peak load and are on demand

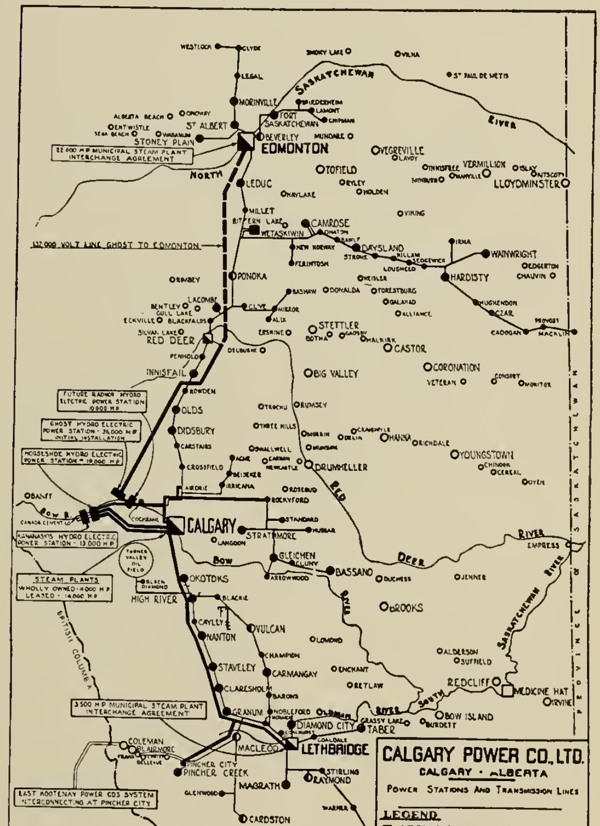


**Fig. 1—Calgary Power Company System in 1930.**

during periods of high water only. This is important in an area where climatic conditions and mountains place limitations on hydraulic power station output during the winter peak load period.

During the past decade many small steam, natural gas, semi-Diesel and Diesel plants have been taken out of service and dismantled. Privately owned companies have constructed transmission lines reaching the towns and villages formerly served by these small fuel plants. The extent of the activities in Alberta of one of these

TABLE I
PERFORMANCE DATA OF CENTRAL STATIONS FOR THE PERIOD NOVEMBER 30TH, 1934 TO NOVEMBER 30TH, 1935

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | Name of station<br>Owner | Calgary<br>City of Calgary | Edmonton<br>City of Edmonton | Lethbridge<br>City of Lethbridge | Saskatoon<br>Saskatchewan Power Commission | Sentinel<br>East Kootenay Power Co. | Moose Jaw<br>National Light and Power Co. |
| 2 | Location | Calgary, Alberta | Edmonton, Alberta | Lethbridge, Alberta | Saskatoon, Sask. | Sentinel, Alberta | Moose Jaw, Sask. 1936 |
| 3 | Operating pressure and temperature | 150 lb. per sq. in.<br>485 deg. F. | 165 lb. per sq. in.<br>550 deg. F. | 272 lb. per sq. in.<br>580 deg. F. | 400 lb. per sq. in.<br>700 deg. F. | 225 lb. per sq. in.<br>542 deg. F. | 275 lb. per sq. in<br>700 deg. F. |
| 4 | Total installed capacity | 10,000 kw. | 21,000 kw. | 5,075 kw. | 20,000 kw | 10,000 kw. | 21,000 kw. |
| 5 | Unit capacity of turbines and r.p.m. | 5,250 kva.<br>2,500 kva.<br>1,600 kva. | 10,000 kva. } 3,600 r.p.m.<br>5,000 kva. }<br>4,000 kva. 1,800 r.p.m.<br>2,000 kva. 3,600 r.p.m. | 3,375 kva. }<br>1,200 kva. } 3,600 r.p.m.<br>500 kva. } | 10,000 kva. }<br>5,000 kva. } 3,600 r.p.m.<br>3,200 kva. }<br>2,000 kva. 1,800 r.p.m. | 2 of 5,000 kva. 3,600 r.p.m. | 10,000 kva. }<br>5,000 kva. }<br>3,500 kva. } 3,600 r.p.m<br>1,500 kva. }<br>1,000 kva. } |
| 6 | Type and size of steam reheater in sq. ft. H.S. | None | None | None | None | None | None |
| 7 | Number of bleeder heaters | None | None | None | 2 | 1 | None |
| 8 | Final temperature of feed, full load | 200 deg. F. | 250 deg. F. | 207 deg. F. | 300 deg. F. | 208 deg F. | 200 deg. F. |
| 9 | Total number of boilers | 20 | 17 | 2 | 10 | 3 | 6 |
| 10 | Square feet of boiler surface per unit | A-16—3,000<br>B- 4—6,000 | A-8—4,050 B-8—4,780<br>C-1—12,907 | 5,040 | A-8— 4,928<br>B-2—10,628 | 6,650 | 2—6,010<br>4—3,750 |
| 11 | Square feet econ surface per unit | None | None | 1,100 | A—(serves 2 units)<br>B— None | None | None |
| 12 | Square feet air preheater surface, per unit | | 10,136 | None | A— None | None | 7,040 |
| 13 | Maximum boiler output per unit, lb. per hr. | 27,500 | 120,000 | 48,000 | A— 30,000<br>B— 85,000 | 50,000 | 60,000 |
| 14 | Average boiler plant efficiency, per unit | 69% | A and B —<br>C 76% | 78.6% (1936) | A— 67%<br>B— 72% | 80% | 81% |
| 15 | Type of furnace equipment | A—Stoker<br>B—Gas | Stoker | Stoker | Stoker | P.C. | P.C. |
| 16 | Condenser surface, sq.ft. per unit | 7,875 | 12,700 | 4,332 | 10,000 | 4,890 | 10,900 |
| 17 | Maximum cooling water temperature | 60 deg. F. | 70 deg. F | 80 deg. F. | 72 deg. F | 69 deg. F. | 90 deg. F. |
| 18 | Minimum cooling water temperature | 33 deg. F. | 34 deg. F. | 32 + deg. F. | 32 + deg. F. | 35 deg. F. | 40 deg. F. |
| 19 | Gross annual output, kw.h. | | 32,033,400 | 8,550,975 | 39,217,800 | | 28,192,200 |
| 20 | Auxiliary use, kw.h. | | 2,523,100 | 531,670 | 3,937,740 | | 3,169,397 |
| 21 | Net annual output, kw.h. | 10,000 | 29,510,300 | 8,019,305 | 35,280,060 | | 25,024,803 |
| 22 | Average cost of coal. 2,000 lb. per ton | $3.00 | $1.39 | $1.48 | $3.58 | | $3.40 |
| 23 | Average annual station performance, B.t.u. per kw.h. | 31,456 approx. | 43,180<br>D—27,115<br>E—79,050<br>27,600 (1936) | 25,900<br>22,500 (1936) | 22,200 (unofficial)<br>23,000 (1936) | 26,000 | 21,400 (1936) |
| 24 | Annual load factor | standby only | 23.8% | 50% | 42.2% | Standby only | 61.6% |
| 25 | Annual use or capacity | | 17.4% | 29% | 22.4% | | |
| 26 | Remarks | Standby service | D—Base load 6 mos. } 8,000 kw.<br>E—Pumping only 6 mos. } 800 kw. | | | | |

Pressures in lb. gauge. Boiler efficiencies based on higher heating values of fuel. H.S.—Heating surface. P.C.—Pulverized coal.

public utility companies is shown, as at 1930, in Fig. 1. The system includes about 1,700 miles of transmission lines and reaches 136 communities with a combined population of more than 250,000. The installed capacity of this company's hydro-electric plants comprises more than 98 per cent of the developed water power in the province.

The larger fuel plants which have been retained in service, have undergone a gradual and normal process of development. Higher pressures and temperatures have been adopted and steam generating plants have been equipped for burning the cheaper fuels as they have become available. One of the earlier plants to adopt pulverized coal has reverted to standby service. A limited number of plants have been designed to operate on alternative fuels including bituminous and lignite* coals,[1] and oil. The majority of the plants are equipped with forced draft chain-grate stokers. One plant has been designed to burn low rank pulverized coal.

Of the six larger fuel stations, four are owned and operated as municipal enterprises. One is operated by a provincial power commission; two are privately owned and operated.

Old plant in fuel stations is characterized by lower operating pressures and temperatures, smaller boilers and furnaces, and fewer heat-recovery devices than have been provided in the modern equipment installed in the larger stations. Three of the plants operate at 400 lb. per sq. in. and 700 deg. F. Two of the 3,600 r.p.m. condensing turbines were the first to operate at capacities of 10,000 kw. and 15,000 kw.; the former is at Edmonton (1928) and the latter at Regina (1930).

### Thermal Station Performance

Thermal performance of certain Canadian stations for the period, November 30th, 1934 to November 30th, 1935, is summarized in Table I. The performance may be expected to show improvement as a larger fraction of the station operates at the higher pressures and temperatures, and advantage is taken of available heat cycles,[2] heat-recovery devices and superposed plant.[3]

Superposition consists in the addition of new high-pressure, high-temperature, low heat-drop turbines which receive high-pressure steam from new high-pressure boilers, exhaust into the old low-pressure mains and, through the serviceable old low-pressure turbines, to the condenser. The combination is equivalent to a compound unit. An extraction feedwater heater may be provided to operate at the throttle pressure of the low-pressure turbine. Superposition has the advantage of increasing station capacity of high performance equipment, and of improving the station performance. The cost is limited to the turbine, generator, piping and switching arrangements. The turbine may be placed near the new high pressure boiler plant and thus save the cost of extension of high pressure piping.

The electric energy generated and the distribution between fuel and hydraulic stations for the period 1926-1936, is shown in Fig. 2. The net annual output of five stations is shown in Fig. 3; annual load factor in Fig. 4; station performance in Fig. 5; auxiliary power in Fig. 6; feedwater make-up in Fig. 7; fixed charges on plant in Fig. 8 and fuel cost in Fig. 9. The outage of the largest turbine appears in Fig. 10 and the outage of the largest boiler in Fig. 11.

### Steam-Generating Plant

The coal consumption in pounds per kw. hour has been reduced from 3 to about 1½ during the last twenty-five years. Contributing factors are the practical application of the regenerative cycle, higher pressures and temperatures, and increase in the size and efficiency of steam turbines. Improvements in the turbine room have been followed by a similar transformation in steam-generating plant. A high pressure boiler having an output of 1,250,000 lb. per hour is in service. In one of the newer stations of the United States, the 80,000 kw. turbine is served by a single boiler. The station has set a record of 11,166 B.t.u. per kw. hour for the first five months of operation. Average boiler plant efficiency for 1935 in large modern stations ranges from 83 to 87.5 per cent. Pressures have increased to 1,400 lb. per sq. in., temperatures to 1,000 deg. F. and ratings to 500 per cent.

Modern steam-generating plant, with a view to a minimum cost per unit of steam generated, is characterized by an equitable distribution of the heating surface between the waterwalls, boiler tubes, superheater, and heat-recovery devices such as the economizer and air preheater, having regard to the individual conditions of operation, choice of fuel or fuels, and fuel burning equipment.[4] Economic operating conditions of pressure and temperature are determined by the turbine heat balance.[5] The central stations with which this paper is concerned, having an installed turbine capacity of 20,000 kw. or over, have adopted a pressure of 400-430 lb. per sq. in. and temperatures of 700-825 deg. F. Earlier experiences in the burning of low rank Alberta coals, early designs of boilers, furnaces and stokers and their performance have been discussed[6] elsewhere by the author.

Typical steam-generator installations are shown in Figs. 12 to 18. One of the largest steam generators in Canada is the 1,650 hp. unit in the Regina station, shown in Fig. 12. This generator is designed to produce a maximum of 205,000 lb. of steam per hour at a pressure of

*The term "lignite" coal is taken from "Central Electric Stations in Canada."

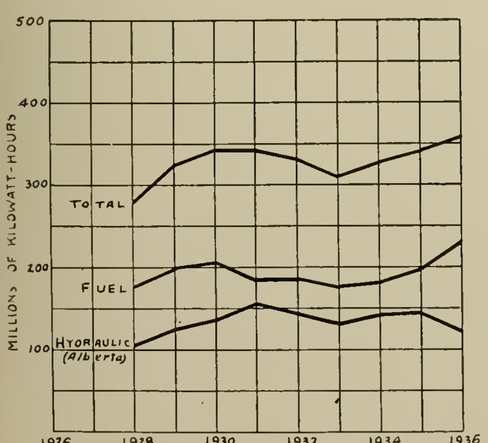


Fig. 2—Electrical Energy Generated in Alberta and Saskatchewan.

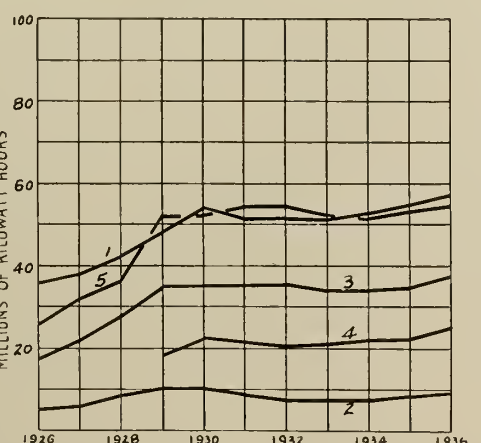


Fig. 3—Net Annual Station Output.

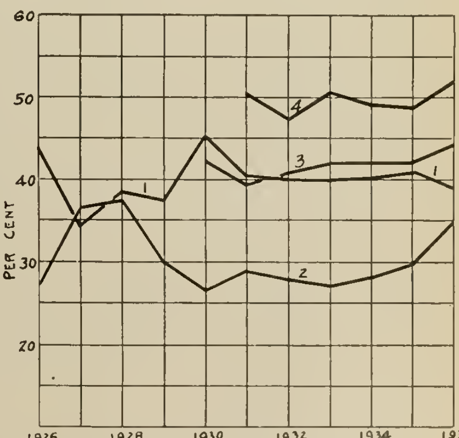


Fig. 4—Annual Load Factor.

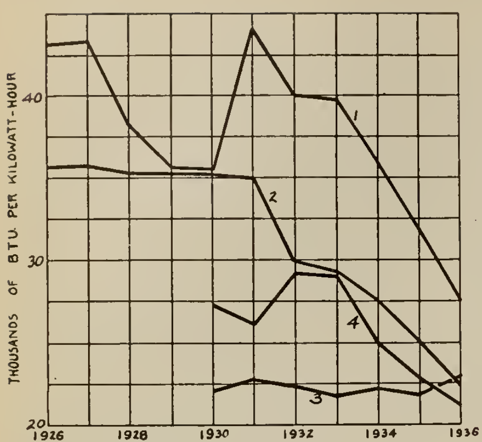


Fig. 5—Station Performance Net.

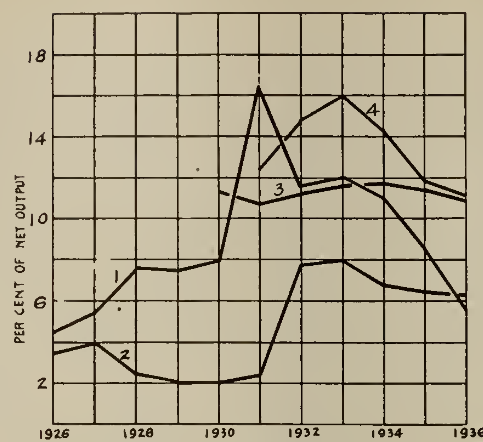


Fig. 6—Auxiliary Power.

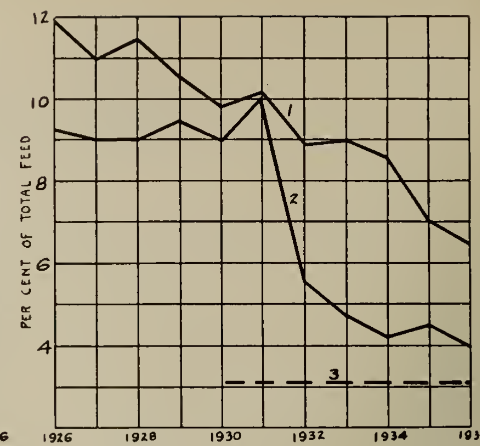


Fig. 7—Feedwater Make-up.

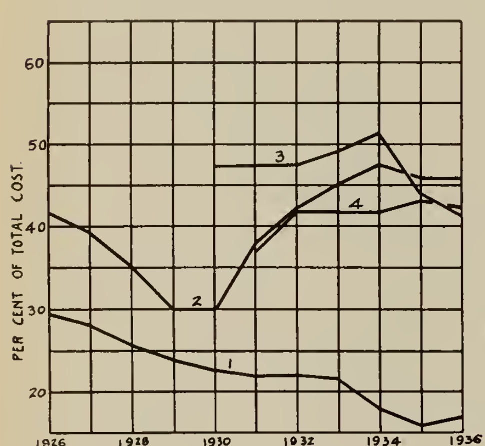


Fig. 8—Fixed Charges.

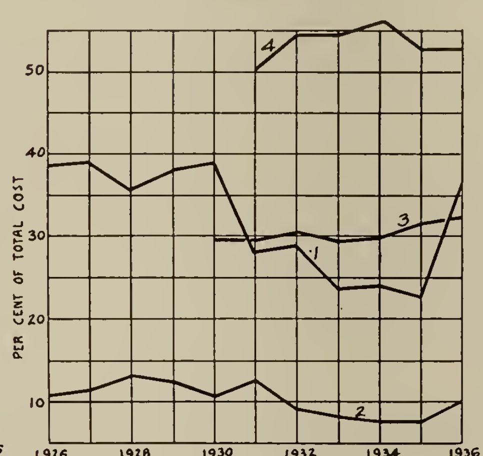


Fig. 9—Fuel Cost.

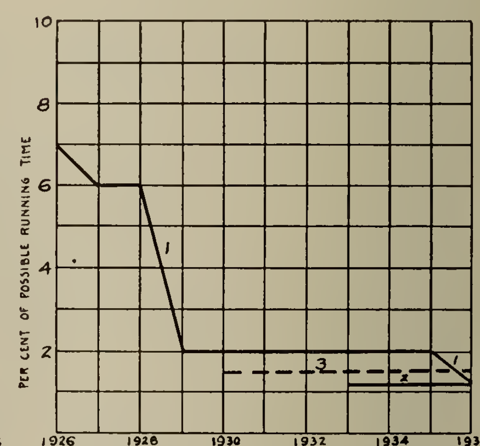


Fig. 10—Outage of Largest Turbine.

400 lb. per sq. in. and 743 deg. F. with gas as fuel (although a natural gas supply was contemplated it has not been provided at Regina to date) or to burn powdered bituminous coal or lignite. It consists of a water and steam cooled furnace, 4-drum bent tube boiler, combination superheater and tubular air preheater. A new unit now being installed at the Regina plant is described[7] in another paper in this symposium.

Data for certain western Canadian steam generating plants are shown in Table II for the period November 30th, 1934 to November 30th, 1935. Approximate performance data for four units are shown in Table III; operating conditions of seven units installed 1928-30 are given in Table IV.

### Boilers

The bent-tube type of boiler has been chosen for all recent installations of large high pressure units. The majority are of the Stirling type, with the exception of Regina, Fig. 12, and Moose Jaw, Fig. 18, which burn pulverized coal, all are equipped with chain or travelling grate stokers. In certain cases, stokers were installed in place of pulverized coal for the reason that it was not desirable to discharge powdered coal ash from the stack over the surrounding city. At that time methods for dust removal from flue gases had not been successfully developed. Today the efficiency of dust recovery with precipitators ranges from 90 to 95 per cent. It is noted that when the design conditions of a boiler differ from those on which it is operating, this difference has an effect on the performance of the boiler.

Moderate ratings of 200-300 per cent are favoured. Boiler drums are of liberal proportions and are riveted. The average availability of the Edmonton boiler was 96 per cent in 1933 and 97.5 per cent in 1936. The Regina boiler is shut down twice a year for cleaning and inspection, each period usually taking two weeks. The Lethbridge boiler is shut down for cleaning and inspection every three months. The one-boiler one-turbine system is favoured as the modern trend and has been adopted in certain plants. One station has operated with one boiler and one turbine for over five years, excepting for the periods of shut down of each, and has never had a shut down due to a fault in either boiler or turbine. Availability of the Saskatoon boilers is about 97½ per cent. Steam scrubbers, or steam washers for removing moisture and avoiding the carry-over of dissolved solids, have not been adopted but dry pipe separators are used.

*Superheaters*

With the single exception of Regina, all superheaters in recent installations are of the convection type described as "pendant." The Regina boiler has the combination of convection and radiant types which has the advantage of producing a flat superheat curve with a varying steam output. Experiences with combination superheaters are described[8] elsewhere. As an alternative to the radiant superheater, a disposition has been shown, notably at the Picture Butte plant of the Canadian Sugar Factories, to place the convection superheater nearer the fire so that less boiler surface is between it and the furnace, as shown in Fig. 17. One plant reports that a damper regulator limits the variation of superheat, over the operating range, to 10 deg. F. One plant reports drainage facilities for the convection superheater. The combination type is drained. One operator of a stoker-fired plant reports trouble in controlling superheat and is inclined to blame the furnace design in which laning or streaking

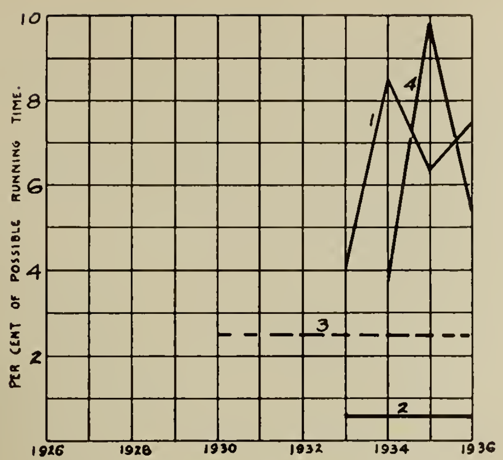


**Fig. 11—Outage of Largest Boiler.**

of the fire occurs. Provision for dust and slag removal from the superheater tubes, is usual.

*Air Preheaters*

In the case of stoker installations, preheated air is often used in conjunction with an economizer to insure proper heat-recovery. The distribution of heating surfaces between these units depends upon their respective costs in individual cases. One of these units may be omitted. At the Delray station of the Detroit Edison Co. preheated air at 500 deg. F. has been used.[9] Stoker grate bars must be properly ventilated to withstand the temperatures involved. Not less than four air preheaters are in service in the stations under review and the plate, regenerative and tubular types are represented. Temperatures range from 300 to 400 deg. F. One of the smaller stations omitted the air preheater, the economizer serving instead for heat recovery. The stoker, however, is designed to permit the use of preheated air to 450 deg. F. One of the larger plants, in which the furnace walls are air-cooled, omitted the economizer. No trouble has occurred from wear or fouling with flue dust.

*Economizers*

Both the integral and external types of economizer are in service. An example of the former is shown in Fig. 15. The feedwater is supplied to this economizer at 210 deg. F. and no trouble arises from corrosion or deposit of flue dust. This temperature is within 10 degrees of the 220 deg. F. commonly adopted.

*Boiler Feedwater*

The adoption of high pressures and temperatures requires very careful attention to the quality of the feedwater for the boiler and the conditions which obtain in the boiler itself. A notable reduction in the percentage of make-up required to compensate for leakage, soot blowing and vent losses, is shown by certain representative plants during the last five years in Fig. 7. The practice of supplying only deaerated distilled water to the boiler is usual in the larger high-pressure, and some of the smaller, stations. Substantial returns are yielded even in the smaller low-pressure plants in the form of reduction in costs for boiler cleaning, replacements due to corrosion, and excessive blowing down of the boiler to avoid high concentration of solids and carryover.

Single- or double-effect evaporators, having effective descaling features are added to the turbine heat balance, together with an evaporator condenser and raw water heater. Mechanical deaeration of all feed to the boiler is provided by an open deaerator heater in which high pressure steam is bubbled through the feedwater. The feedwater in the heater requires to be at the same temperature as the steam in the heater. The air is entrained by the bubbles of the high-pressure steam and discharged to the atmosphere through the heater vent, which is equipped with a gleaner condenser. The purpose of this condenser is

Table III

Approximate Performance Data for Four Steam-Generator Units, Fuel-Types and Characteristics

| | Dominion Gas & Electric Co. Prince Albert | Canadian Sugar Factories Picture Butte | City of Edmonton | City of Saskatoon |
|---|---|---|---|---|
| Steam output.........lb. per hr. | 40,000 | 60,000 | 80,000 | 60,000 |
| Steam pressure.........lb. gauge | 325 | 250 | 180 | 400 |
| Steam temperature.......deg. F. | 625 | 510 | 590 | 710 |
| Feed temperature........deg. F. | 195 | 220 | 250 | 300 |
| Exit gas temperature.....deg. F. | 240 | 520 | 400 | 241 |
| Preheated air temperature.deg. F. | | | 320 | 365 |
| Economizer outlet temperature...........deg. F. | 330 | | | |
| Per cent excess air.............. | 130 | 140 | 140 | |
| Coal—district.................. | Drumheller | Lethbridge | Edmonton | Drumheller |
| Coal—B.t.u. as fired............ | 9,000 | 10,000 | 8,750 | 9,000 |
| Coal—moisture as fired...per cent | 18.8 | 14.0 | 22.5 | 18.8 |
| Boiler—type.................... | Stirling | Stirling | Stirling | Stirling |
| Boiler sq. ft. heating surface..... | 5,531 | 7,075 | 12,907 | 10,629 |
| Sq. ft. grate surface............. | 148 | 214 | 370 | |
| Overall efficiency........per cent | 80.5 | 75.5 | 80.5 | 76.5 |

Table II

Boiler Data

| Name of station | Year installed | Manufacturer | Pressure lb. per sq. in. | Temp. deg. F. | Heating surface sq. ft. | Maximum rating lb. steam per hr. | Lb. steam per sq. ft. heating surface per hr. | Furnace volume cu. ft. | Heat liberated B.t.u. per cu. ft. per hr. | Furnace bottom |
|---|---|---|---|---|---|---|---|---|---|---|
| Calgary........... | 1913 | B.W. | 160 | 470 | 6,000 | 27,500 | 4.6 | 1,080 | 38,700 | |
| Edmonton.......... | 1932 | B.W. | 175 | 600 | 12,907 | 120,000 | 9.3 | 3,800 | 29,800 | |
| Lethbridge......... | 1931 | Puget Sound Machy. Depot | 270 | 580 | 5,040 | 48,000 | 9.5 | 1,740 | 38,700 | |
| Saskatoon........... | 1929 | B.W. | 385 | 700 | 10,628 | 85,000 | 8 | 2,883 | 57,400 | |
| Sentinel............ | 1928 | R.E. Co. | 225 | 542 | 6,550 | 50,000 | 7.6 | 3,133 | 20,000 | 2 water-cooled hearth. 1 water screen |
| Moose Jaw.......... | 1930 | C-E | 275 | 700 | 6,010 | 60,000 | 9.98 | 3,000 | 22,700 | Double row screen tubes |

to recover heat otherwise wasted through the heater vent. By this process the oxygen content of the feedwater is reduced to 0.03 c.c. per liter. Residual dissolved oxygen is removed by adding sodium sulphite to the feedwater as it enters the boiler, and should be practically zero by the Winkler test. Where economizer protection is desired, a continuous feed of sodium sulphite before the boiler feed pump suction, is preferred. The use of sodium

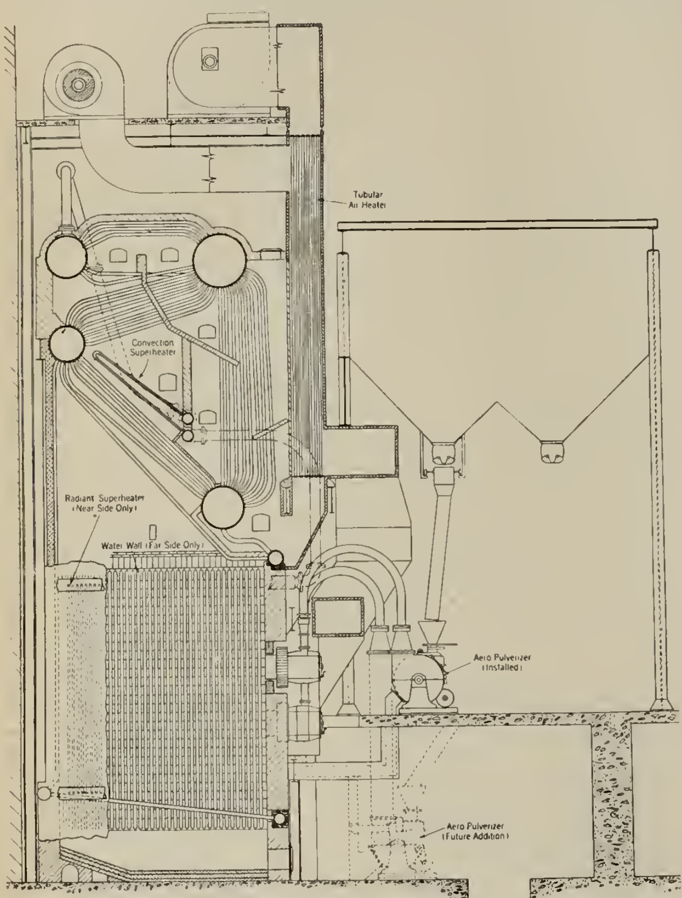


**Fig. 12—Boiler 9, City of Regina Municipal Power Plant.**

sulphite has been reported[10] as satisfactory in laying up idle boilers filled with water when a *pH* or "acidity index" value of 11.6 or higher and a residual of 20 p.p.m. or more of sodium sulphite were maintained throughout the boiler.[11]

The boiler damage, which has been ascribed to the condition of the feedwater in the boiler and named "caustic embrittlement," has been observed in certain areas of this continent and abroad. The earlier investigations have been discussed[12] elsewhere. This phenomenon was exhibited as higher pressures and temperatures were adopted in boilers having riveted drums. The conditions which cause caustic embrittlement of boiler material, its detection and the control of feedwater conditions to prevent its action are now understood and have been discussed[13] elsewhere. Current practice in the central stations of the United States has been summarized.[14] High alkalinity of the water in the boiler drum is maintained to reduce corrosion. A *pH* value of 9.6 is considered necessary and with high silicates may be as high as 11. High alkalinity at high boiler pressures requires a large amount of sodium sulphate to maintain the A.S.M.E. sulphate-alkalinity ratio to inhibit caustic embrittlement. Sodium phosphate is used at times to reduce the quantity of sulphate necessary to control residual hardness from condenser leakage and to lessen boiler-water concentration. An example of the variation in the composition of river water is shown[15] in Table V.

Reduction in the percentage of make-up of feedwater necessary simplifies the problem of chemical treatment. Pieces of polished boiler plate have been used as detector rods for corrosion. The importance of an accurate knowledge of the conditions of the feed- and boiler-water and adequate means for its control cannot be stressed too strongly.

Reserve storage of distilled feedwater amounts to from 0.5 to 1.35 imperial gallons per kw. of capacity as compared to 2 U.S. gallons in some of the large stations.

Table V

Analyses of North Saskatchewan River Water at Edmonton
Parts per million

| | |
|---|---|
| Total solids | 165-320 |
| Calcium sulphate | 21- 95 |
| Calcium carbonate | 51-149 |
| Magnesium carbonate | 25- 84 |
| Sodium chloride | 2.5- 7.4 |
| Silica | 0- 15 |
| Alkalinity | 105-225 |
| Total hardness | 120-295 |
| Carbonate hardness | 105-225 |
| Non-carbonate hardness | 15- 70 |

### Fuels

Analyses of Alberta coal have been published.[16] The burning of low rank Alberta coals, combustion and control, is discussed[17] in another paper of this series.

Table IV

Operating Conditions of Seven Steam-Generator Units Installed 1928-30—Rating and Method of Firing

| Date installed | Name of company | Location | Make of boiler | Type boiler | H.p. | No. of boilers | Steam pressure lb. per sq. in. | Superheat deg. F. | Rating | Method of firing |
|---|---|---|---|---|---|---|---|---|---|---|
| 1928 | Union Power Co. Ltd. | Drumheller, Alta. | Kidwell | S.V. | 492 | 2 | 200 | 150 | 200% | Stoker |
| | Union Power Co. Ltd. | " | B. & W. | H.W.T. | 500 | 1 | 150 | 150 | 200% | Stoker |
| 1928 | City of Prince Albert | Prince Albert, Sask. | Connelly | S.V. | 470 | 1 | 250 | 150 | 175% | Stoker |
| 1928 | Nat. L. & P. Co. | Moose Jaw, Sask. | C-E Heine | S.V. | 600 | 1 | 275 | 290 | 44,000 lb./hr. | Pulv. fuel |
| 1929 | Sask. Power Comm. | Saskatoon, Sask. | B. & W. | S.V. | 1,000 | 2 | 400 | 287 | 90,000 lb./hr. | Stoker |
| 1929 | City of Prince Albert | Prince Albert, Sask. | Connelly | S.V. | 470 | 1 | 250 | 150 | 200% | Stoker |
| 1930 | Nat. L. & P. Co. | Moose Jaw, Sask. | Heine | S.V. | 600 | 1 | 275 | 290 | 44,000 lb./hr. | Pulv. fuel |
| 1930 | Dom. Electric Power Company | Estevan, Sask. | Connelly | S.V. | 320 | 2 | 250 | 100 | 175% | Stoker |

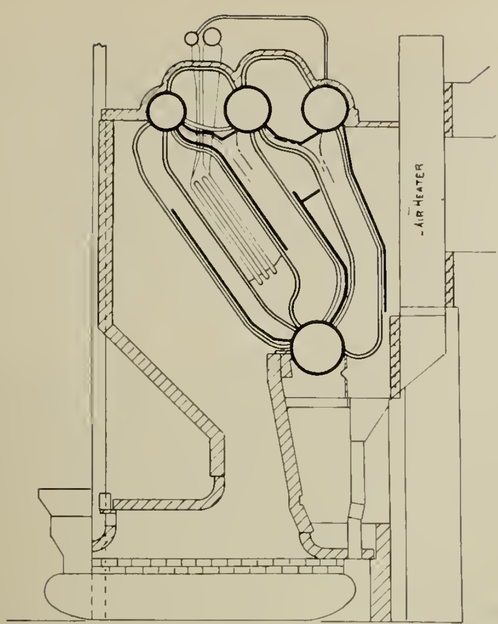

**Fig. 13—B-W Steam Generator with Tubular Air Preheater, Harrington Stoker and Air-Cooled Furnace. Edmonton Station.***

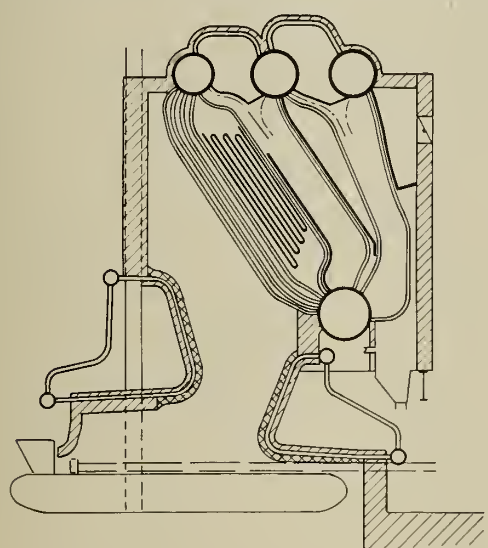
**Fig. 14—B-W Steam Generator, Chain Grate Stoker, Water-cooled Front and Rear Arches. Saskatoon Station.***

A classification of Canadian coals has been proposed,[18] and the composition of Canadian coals has been described[19] elsewhere. Coal friability tests have been conducted[20] and reported on.

*Coal and Ash Handling*

Clam shell buckets are in use for handling both coal and ashes. Crushers have been located over the coal bunkers and under the firing floor. In one plant the coal is burned as received and without crushing. Roll jaw crushers and ring crushers are used. A skip or bucket is used to elevate the coal, and a belt conveyor for distribution to the bunker. A suspended catenary bunker has been provided in one of the recent installations. Coal storage areas range up to 1.25 acres. High moisture coals tend to give trouble from spontaneous ignition in storage piles. It has been stated that the size and temperature of the coal when it is put into the pile are important factors in determining the heating effect, and coal between ¾ in. and 1½ in. in size stored during warm weather gives the greatest amount of trouble. Further, that fine coal stored during the winter months gives little trouble even over a period of months. During very cold weather, high moisture coal supplied from a storage pile which has become mixed or impregnated with snow requires heating to prevent caking or arching in the hopper of the stoker.

Three methods of removing ash are employed, by car from ash pits in dry form, by steam jet conveyor and by hydraulic sluice. Trouble has resulted from the freezing of discharged ash. When the ashes are handled in dry form adequate ventilation of ash tunnels is required. Ashes and cinders are used for street maintenance in certain cases.

Trouble has been experienced with segregation of the coal in the pipes leading from bunker to stoker, causing an uneven fire. Segregation of the fuel may occur in the stoker hopper as a result of poorly sized and prepared fuel. Laning or streaking of the fire has been ascribed to this segregation. A device, installed at the Picture Butte plant to prevent segregation is illustrated in Fig. 19.

*Pulverizers*

The two pulverized coal stations in active operation are Moose Jaw and Regina. The performance of the former is shown in Table I, and that of the latter is discussed[7] elsewhere.

At the National Light & Power Company plant at Moose Jaw are installed two C-E (Heine) bent tube, 4 drum, boilers (shown in Fig. 18), 7,000 sq. ft. heating

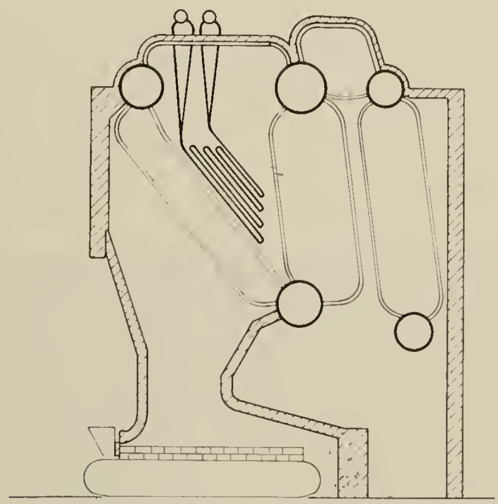
**Fig. 15—Stirling Boiler with Economizer Coxe Stoker and Rear Arch Furnace. Lethbridge Station.***

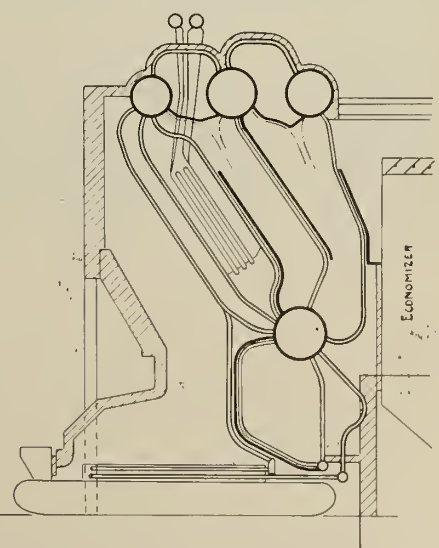

**Fig. 16—Stirling Boiler, Water-cooled Rear Arch and Side Walls along Stoker Grate Line. Prince Albert Station.**

*See Table II for details.

surface each, design pressure 275 lb. per sq. in. with 260 lb. at the superheater outlet. Both side walls are water cooled with finned tubes, while the rear and bottom have plain tubes. Each unit has two Raymond No. 50 high speed (impact) pulverizers and two type "D" 20 in. burners. The first unit installed in 1929 is equipped with a Riley (Thermix) air preheater, and the second (1930) a C-E plate type air preheater of 7,040 sq. ft. heating surface. The capacity of each unit is 45,000 lb. per hour

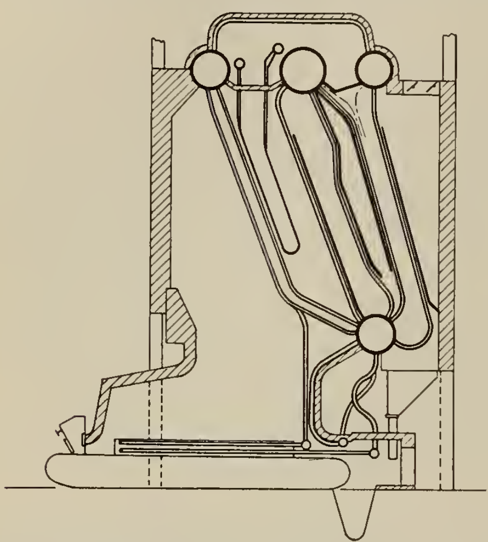

**Fig. 17—Stirling Boiler with Dutch Oven, Water-cooled Rear Arch and Side Walls above Stoker Grate Line. Picture Butte Station.**

with a maximum of 60,000 lb. per hour. This plant burns all western Canadian coals as well as fuel oil or natural gas, if available.

At the city of Regina plant in Regina the pulverized coal equipment consists of a Foster-Wheeler (Kidwell) 4-drum bent tube boiler (shown in Fig. 12), 16,500 sq. ft. heating-surface, design pressure 400 lb. per sq. in.; water walls with tile back 1,452 sq. ft.; ash pit screen 1,349 sq. ft.; furnace volume 13,000 cu. ft. above ash pit screen; convection superheater extended surface, one loop, 66 units 35 ft. long; radiant superheater in furnace, 34 units 2 in. diameter, 19 ft. long; air heater 20,240 sq. ft.; pulverizers, B-W pressure type ball mill rated at 12,000 lb. per hour on coal having a grindability factor of 82 per cent.

This plant also is capable of burning all Western Canadian coals and/or oil.

Lignite coals grind easily in spite of the high moisture content. It is necessary, however, to pass about 50 per cent more air through the pulverizer on account of the high moisture content, it being necessary to furnish the larger weight of air in order to remove sufficient moisture to grind the coal. There is probably about 7 to 10 per cent of moisture remaining in the coal in its pulverized form. 18 to 19 kw.h. per ton are required for certain Alberta lignite coals compared with 12 to 14 kw.h. per ton for Alberta bituminous coals and 19 kw.h. per ton for Saskatchewan lignite. Analyses of these coals have been published.[16] Pulverizing capacity of the mill is reduced about 25 per cent when grinding lignite coal as compared with bituminous coal. The percentage of pulverized lignite coal passing through the 40,100 and 200 mesh screens is reduced considerably. One of the Regina mills has ground more than 70,000 tons of fuel with the original grinding elements, and has done this without a decrease in the original fineness.

### Furnaces

Zoned air control in chain grate stokers which burn lignite and sub-bituminous coals is generally satisfactory. Difficulty arises when more than the requisite number of zones are provided, in that it takes too long for the fireman to examine the fire and then rearrange the dampers to suit conditions in the furnace. This condition results in a lack of flexibility. In one case the design provided for combustion rates from 15 to 57 lb. of coal per sq. ft. of grate surface per hour and a good average is 40 to 45 lb. The latter gives a heat release per foot of width of 7.4 million B.t.u. per hour.

One of the recent stokers burned an average of 37 lb. of lignite coal per sq. ft. of grate surface in 1936, with a heat release per foot of width of 5.75 million B.t.u. per hour. A smaller stoker burned a maximum of 52 lb. of sub-butiminous coal with an average of 17 lb. The maximum heat release per foot of width is 6.85 million B.t.u. per hour. No recent installations of underfeed stokers have been made in central stations. One of the older stokers, installed to provide flexibility, exposed capacity limitations at a moderate rating. Difficulty arose from slagging due to the moderate fusion temperature of lignite coal, as follows: Tofield, 2,000 deg. F.; Edmonton, 2,100 deg. F. and for slack, 1,800-2,000 deg. F.; Coalspur, 2,000-2,300 deg. F.; Pembina, 2,400 deg. F.; Lethbridge sub-bituminous, 2,100 deg. F.; and bituminous, 2,200-2,800 deg. F. Satisfactory performance was not obtained, for example, with slack from the Edmonton area, although this trouble does not occur when the slack is burned on chain grate

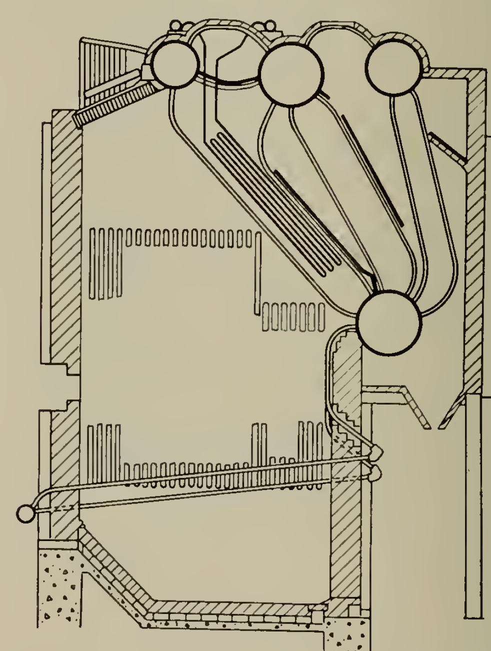

**Fig. 18—C-E Bent Tube Boiler, Waterwalls, Type D Burners and Air Preheater. Moose Jaw Station.***

stokers. The recent developments of providing water-cooled piping above the tuyères,[21] overfire air, carborundum extension grates, and water-cooled side walls are promising in view of the lower cost of underfeed stokers. Two pulverized coal plants are equipped for burning oil simultaneously with the coal.

In one station automatic draft-control equipment is provided in connection with an automatic stoker in an old plant. In new steam-generating plant, hand control is adopted for the stoker and combustion-control,

*See Table II for details.

the latter being the usual arrangement. Maintenance cost on this equipment is reported as low.

The trend in furnace design is toward a completely water-cooled furnace, with combustion space of ample proportions to allow combustion to be completed before the tube bank is reached. Furnace temperatures are maintained by employing refractory or cast iron protection for the tubes on the furnace side.

Table I shows a tendency to high values for heat release per cubic foot of furnace volume. The practice has been to allow higher values of heat-release with coals in which the fusion temperature of the ash is low, and lower heat-release values when the fusion temperature of the ash is high; the older values for design are 12,000, 17,000 and 34,000 B.t.u. per cu. ft. of furnace volume per hour for refractory, air-cooled and water-cooled furnaces respectively. Recent installations have lower values as, for example, at Port Washington, a large steam generating unit with water cooled walls, in which the heat release is only 15,000 B.t.u. per cu. ft. per hour. Excessive heat release values tend to shorten the path from the grate to the tube bank and result in imperfect combustion. They also lead, especially in the case of refractory walls, to abnormal maintenance costs.

*Stoker Fired Installations*

Typical stoker fired units are to be found at Edmonton, Lethbridge, Picture Butte and Prince Albert. The Edmonton unit, Fig. 13, consists of a Harrington travelling grate, 20 ft. wide by 18 ft. long, driven by a 10-hp. motor through a Reeves variable-speed reduction gear. Forced draft is supplied through six compartments. A large triangular front arch facilitates ignition. Side walls are air cooled and fitted with shaped carborundum bricks, intended to prevent building up of ash and slag on the furnace walls. The bricks begin 2 ft. from the hopper and extend for 13 ft. 6 in., to a height of 10¾ in. above the grate. Rear arches are also installed. Air to the stoker is at 300 deg. F. The fuel is Edmonton lignite coal, crushed to 1 in. and under. The furnace volume is 3,800 cu. ft.

At the city of Lethbridge plant, two Coxe travelling grate stokers, 9 ft. 8⅝ in. wide and 13 ft. 8 in. long, have been installed under two bent tube Stirling type boilers, shown in Fig. 15. These have 5,000 sq. ft. heating surface each. The boilers were designed for 272 lb. per sq. in. and 580 deg. F. and have a maximum rating of 48,000 lb. per hr. each. The furnace volume is 2,000 cu. ft. The fuel burned is Lethbridge high ash clinkering coal.

The Picture Butte boiler of Canadian Sugar Factories and the Prince Albert boiler of the Dominion Gas and Electric Company, have been equipped with water-cooled bridge walls of the stud-tube type shown in Fig. 20. This construction eliminates the structural difficulties often encountered in supporting a large refractory bridge wall, and maintenance at this point.

*Waterwalls*

Waterwalls of bare tubes, fin-tubes, block-covered, and stud-tubes are in use. Stud-tubes, covered with refractory material, have less tendency to overcool the furnace than the bare tubes.

Trends in furnace design are toward completely water-cooled furnace walls. Nearly one-sixth of the total heating surface is installed in the furnace and this radiant heating surface yields about half of the boiler capacity. It has been stated that, for western coals, a completely water-cooled furnace cannot be justified on a stoker installation, and water-cooling of the side walls, at least along the stoker grate line, will probably be essential on large installations. This eliminates the trouble caused by ash and slag building up on the furnace walls and interfering with the movement of the fuel along the stoker.

*Dust Removal from Flue Gases*

Considerable progress has been reported from England and the United States in the removal of flue dust discharged from pulverized coal furnaces and in the design of cinder catchers to remove cinders which are characteristic of certain stoker installations. Electro-static precipitators have an efficiency of from 90 to 95 per cent, and dust catchers of the cyclone type, 70 to 90 per cent. Film and spray washers, cinder traps, dust catchers, cinder vane fans and other devices are also in use.

Consideration of this rather costly service will be required in future installations of large steam-generating plant located within or close to city limits.

*Boiler-Auxiliary Plant*

Soot blowers continue in common use and the practice of employing the hand lance as a finishing operation in places not reached by the soot blowers has not been adopted. Some difficulty has been caused by failure of the blowing elements. Loss of treated condensate is offset by the added convenience of the soot blowers. Hydraulic couplings for fan regulation have not been employed. A single preference has been expressed for this device on future installations.

Forced draft fans have been operated by a turbine operating at high pressure and exhausting into the mains of the old low pressure plant. Induced draft fans are served by two direct connected motors, one having two and one half times the capacity of the other.

### Piping

Welding of boiler drums (to prevent caustic embrittlement) and of piping throughout the plant has not been generally adopted. The art of welding and methods for inspection of welded joints have been highly developed in recent years and offer useful benefits in the case of larger installations. Piping materials and welding practice, piping experiences at 1,000 deg. F., and corrugated and creased-bend piping have been discussed[22,23,24] elsewhere.

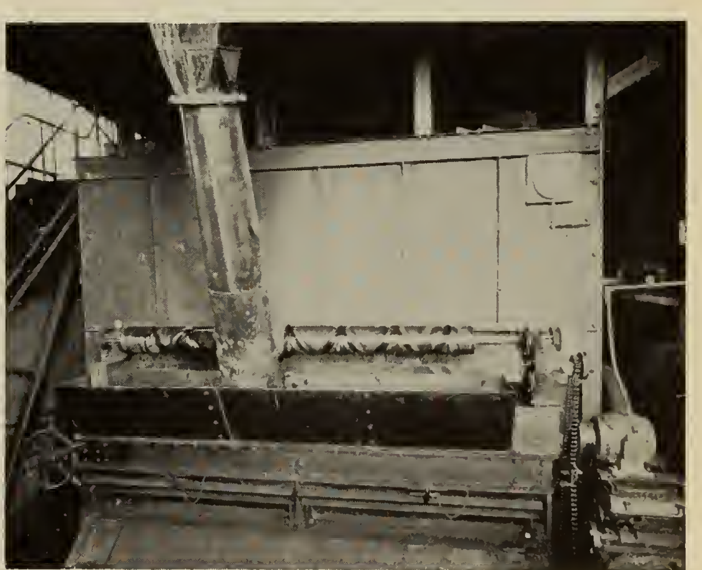

Fig. 19—Traversing Coal Chute.

### Personnel

Large new central station plant offers attractive opportunities for men with scientific training to act as operatives, chemists, etc. Such personnel require laboratory facilities for testing of feedwater, fuels, gases and lubricants. Persistent vigilance in the steam-generating plant is required if satisfactory results are to be obtained.

### Conclusions

Evidence of improvement in the operation of typical central stations is shown in the annual reduction of the station performance and percentage of feedwater make-up. Station load has resumed a normal upward trend. Increased fixed charges reflect the introduction of modern equipment, are moderate and in some cases low. Heat release values tend to be high and furnace volumes low, as compared with modern practice in the larger stations in other places. Low rank Alberta coals are being burned successfully in underfeed stokers at rather low ratings. For larger plants and at medium ratings the forced draft, chain grate stoker is preferred, and where a variety of coals are in competition the pulverized coal furnace is used. The economy to be obtained by the generation of electric energy in high pressure steam turbines which exhaust into low or moderate pressure mains for factory processes or heating, is not generally appreciated, as shown by the fact that various establishments have discontinued generation of power in their own plants and have reverted to the purchase of their energy requirements while operating their steam-generating equipment as a heating system only.

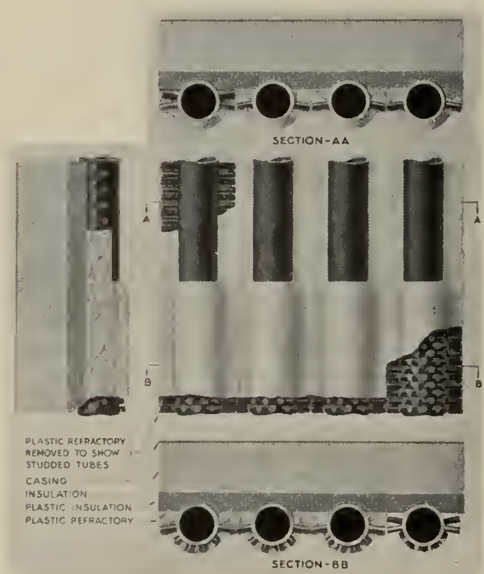


**Fig. 20—B-W Bailey Stud-Tube Furnace Wall. (See Figs. 16 and 17.)**

Architectural design of new station buildings and landscaping of the station grounds have produced more beautiful surroundings. The use of light paint and the omission of partitions have resulted in cleaner and more pleasing interiors. Attention is required in the design of coal and ash handling equipment to insure a fair harmony with station buildings. Recent developments in the art of welding offer advantages which may well receive consideration in the construction of new plant.

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# The Saskatchewan Lignite Industry

## An analysis of recent developments in the industry and the effect of production methods on employment and earnings of labour.

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—Statistics of production are given. The paper discusses causes of the recent expansion of the industry, noting unsatisfactory conditions as to employment and earnings of workers and the provincial legislation which followed. Satisfactory continued development is possible with a smaller number of adequately equipped mines.

The Saskatchewan lignite industry owes its existence to the geographical position of the field in relation to other producing fields and proximity to the more densely populated areas of the prairie provinces. Its future development will depend on the extent to which production methods are adopted which require the minimum capital investment in relation to production value and which, at the same time, reduce the present seasonal fluctuation in employment to a practical minimum. These conditions are essential to the financial stability of the industry and the building of a self-sustaining industrial community.

During the past six years of general economic depression, aggravated locally by crop failures, production in the lignite field has doubled, in competition with overdeveloped production capacity in other fields, for a shrinking market. The increase in production facilities during this period has followed two distinctly different lines, (1) an extension of existing underground methods dependent largely upon hand labour, and (2) mechanized strip mining. The increase in production from the field has been divided about equally between the two methods.

Analysis of statistics covering the past decade shows the trend of development along these two lines and the effect of each on employment. While the available statistics are general in nature and do not permit complete accuracy of analysis, the trends show definitely the dangers of uncontrolled development, and the type of development required for stability of the industry.

An unhealthy condition of employment and earnings of the workers in the underground mines has developed in recent years due to (1) an increase in the range of seasonal production, (2) lack of supervision over wage schedules and working conditions during the earlier years of the period of depression and (3) stabilization of mine prices by operators of the larger mines at levels permitting normally uneconomical operations to develop.

Lignite, as the name implies, is a low rank coal characterized by high moisture and oxygen content. It disintegrates on exposure to weather or heat. The volatile constituents of the lignite found in the northern great plains region contain relatively small proportions of hydrocarbons recoverable as liquid distillates. Its heat value is the lowest of the coals mined commercially in Canada. The characteristic property which offsets the physical and chemical disadvantages and permits its use in the natural state is the greater relative reactivity of the carbon content.

The coal is favourably located for economical recovery, lying in relatively thick horizontal beds, close to the general surface level but protected from weathering by a tight clay cover. In underground workings, roof and floor conditions are favourable and there are no complications from gas or excessive water. Much of the coal lies sufficiently close to the surface to be recovered by strip methods.

The average cost of production, as shown by statistics published by the Dominion Fuel Board, is the lowest in Canada both in actual cost per ton and in relation to heat value.

Capital employed per ton of annual production is lower than in the other western provinces or the average for Canada, but is higher per dollar of value on account of the lower unit value of the coal.

Factors affecting the rate of development of the Saskatchewan industry in recent years may be summed up as follows:—

1. Earlier development of production facilities in competing fields with control of the market;

**Fig. 1—Ten-ton Electric Stripping Shovel Removing Clay Overburden up to 65 Feet in Depth.**

2. A shrinking total market in the western provinces;
3. A localized market due to the low heat value of the product;
4. Seasonal market;
5. Available burning equipment.

1. While the history of the Saskatchewan industry covers practically as long a period as in the other western provinces, production figures are still small by comparison. In British Columbia the peak of production and value was reached in 1920; the peak of value was reached in Alberta in 1920 and of output in 1928. Production and value in Saskatchewan have been increasing to date. Production for use in the natural state has doubled since 1929.

2. Between 1929 and 1935, the last year for which complete data are available, coal consumption in Saskatchewan, Manitoba and Western Ontario, exclusive of locomotive fuel, decreased 900,000 tons or 24 per cent. The total decrease was made up of

(*a*) A reduction of 437,000 tons in shipments from Alberta and British Columbia, and
(*b*) A reduction of 803,000 tons in imports for other than railroad use, offset in part by an increase of 340,000 tons from the Saskatchewan field, which was further increased by 90,000 tons in 1936.

A part of the decrease in coal consumption is accounted for by an increase in the use of wood available because of a temporary employment and economic condition;

part represents reductions due to more economical or efficient use of coal in industrial plants and for domestic heating. An increase in the use of competitive fuels, oil, and electric energy from hydro-electric plants, has also contributed to the reduction in total fuel burned.

3. The practical market available to Saskatchewan lignite is limited by its lower heat value in relation to competitive western coals and coal imported through the western lake ports, to an area roughly determined

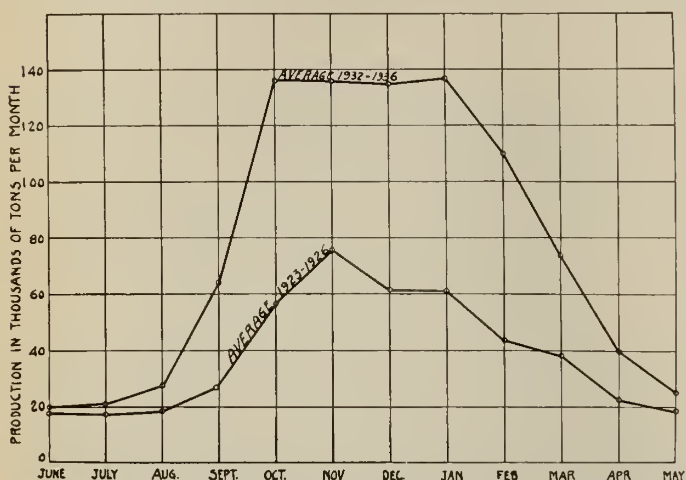


**Fig. 2—Average Monthly Production of Saskatchewan Lignite.**

by a $2.30 freight rate on the east and north and a slightly lower rate to the north-west and west. This potential market area covers approximately 50,000 square miles with a population of about 700,000 people. Freight rates to the larger cities, from Moose Jaw on the west to Winnipeg on the east, range from $1.90 to $2.30 per ton.

4. Production of all coal mined in Alberta and Saskatchewan for domestic and most industrial uses, except part of the locomotive coal, is seasonal and follows weather conditions as measured by degree-day-deficiency. Production in Saskatchewan follows weather conditions more closely than in the other western provinces because,

- (*a*) lignite weathers when stored in open sheds in mild weather;
- (*b*) the additional cost of handling the lower rank fuels through storage adds a greater proportion to the delivered cost than is the case with higher rank fuels;
- (*c*) steam generation of power in the more industrialized portion of the market territory is limited by the availability of low cost hydro-electric power.

Table I and Fig. 2 show production by months for two periods in which annual production for each period was approximately uniform, the average of three and four year periods being used to equalize the effect of variations in monthly temperatures from year to year. It will be noted that while winter production increased about 80,000 tons per month, midsummer production increased less than 4,000 tons per month.

Table I and Fig. 3 show the close relation between monthly production above the midsummer minimum, and degree-day deficiency, when both are expressed as percentages of the total for the heating season. It will be noted that the production curve rises in advance of the degree-day-deficiency curve, due to stocking of coal in the rural districts during the period of grain movement from the farms, and falls off only slightly earlier than the temperature curve toward the end of the season. The degree-day-deficiency curve is based on Winnipeg weather data.

Table I

Production by months for two periods showing relative increase in summer and winter output. Also showing excess of monthly production above midsummer average as a percentage of the seasonal excess by months.

| Month | 1923–1926 | | | 1932—1936 | | | Deg. day deficiency average per cent |
|---|---|---|---|---|---|---|---|
| | Tons | Tons less midsummer average | Per cent of tons for heating season | Tons | Tons less midsummer average | Per cent of tons for heating season | |
| June | 17,606 | | | 20,074 | | | |
| July | 17,373 | | | 21,262 | | | |
| August | 18,034 | 544 | 0.2 | 27,696 | 7,028 | 1.1 | |
| September | 27,724 | 10,234 | 4.1 | 64,672 | 44,004 | 6.4 | 3.65 |
| October | 56,805 | 39,315 | 15.7 | 136,596 | 115,928 | 17.0 | 7.15 |
| November | 76,209 | 58,719 | 23.5 | 136,716 | 116,048 | 17.0 | 11.35 |
| December | 61.746 | 44,256 | 17.7 | 135,455 | 114,787 | 16.8 | 16.35 |
| January | 61,175 | 43,685 | 17.5 | 137,081 | 116,413 | 17.0 | 18.25 |
| February | 43,529 | 26,039 | 10.4 | 110,860 | 90,192 | 13.2 | 17.20 |
| March | 38,327 | 20,837 | 8.4 | 74,553 | 53,885 | 7.9 | 13.40 |
| April | 22.639 | 5,149 | 2.1 | 40,104 | 19,436 | 2.9 | 8.05 |
| May | 18,441 | 951 | 0.4 | 25,797 | 5,129 | 0.7 | 4.60 |

Figure 4 shows the similarity between the production curves for the Saskatchewan and Alberta lignite fields. Production of Alberta lignite leads that in Saskatchewan in the early part of the season and falls off earlier at the end of the season, the slight differences being due to the better storing qualities of some of the Alberta lignites. The production curve for the Alberta bituminous coals, used chiefly for locomotive fuel, shows an almost negligible dependence upon weather conditions.

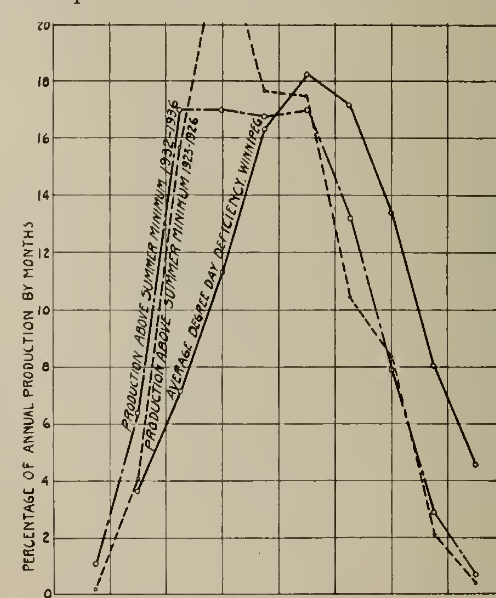


**Fig. 3—Relation of Monthly Production of Lignite to Weather Conditions.**

5. Prior to 1930 the burning equipment installed in industrial plants was designed primarily for burning the higher rank western and imported coals. Since that time many plants, both large and small, in which burning equipment had become obsolete or worn out, have been equipped to burn lignite efficiently.

Lignite production for use as mined has increased from 500,000 tons in 1929 to 1,014,000 tons in 1936. While no accurate data are available it is estimated that of this increase approximately 400,000 tons has been absorbed by the industrial market. At the present time not less than half of the production from the field is used in industrial plants. The large increase in the use of wood due to a temporary economic condition has retarded the rate of increase of lignite for domestic heating.

The increase in the use of Saskatchewan lignite, particularly in industrial plants, has been brought about through

1. Improved preparation of the coal at the larger mines to suit market requirements;

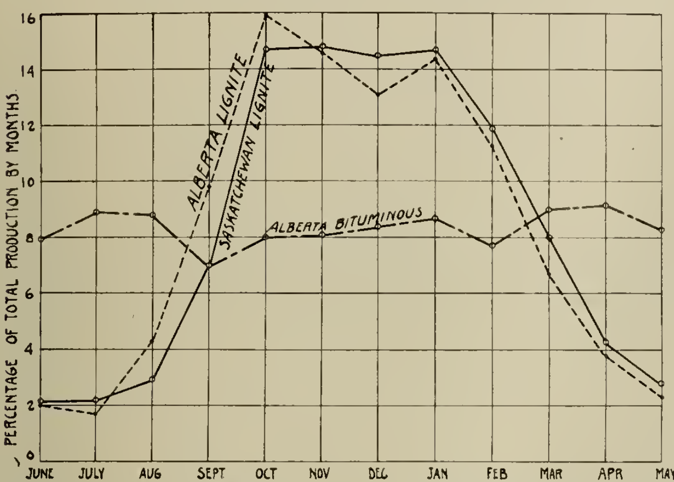


**Fig. 4—Comparative Production for Alberta Bituminous and Lignite and Saskatchewan Lignite Mines.**

2. Promotion of the installation of burning equipment suitable for use with lignite;
3. Co-operation of the Saskatchewan government;
4. Assistance given by the Dominion government in the form of subventions.

Lignite is now available from the larger shipping mines in a range of sizes designed to meet all normal market requirements. The larger sizes are used principally for domestic heating and the smaller sizes for hand fired and stoker fired industrial plants.

The industry has co-operated with manufacturers and plant owners in the design or modification of industrial plants to ensure the maximum economy with the fuel. Several new plants have been designed and built in recent years.

Equipment which has proved most suitable for developing high efficiency with lignite as well as with other available western coals is of two general designs, both of the overfeed type. In smaller plants, or larger plants in which the load factor is relatively low, mechanical coal feeders with non-sifting grates and forced-draft fans have proved most economical. In larger plants, under more nearly continuous load, non-sifting, forced-draft, travelling-grate stokers have been installed. In most cases air-preheaters and induced draft fans have been included with the latter type.

In many hand-fired plants, lignite has displaced coals of higher rank, without change in equipment other than the installation of forced-draft fans. The additional labour for handling the increased quantity of the lower rank fuel has been offset by the reduction in labour for maintaining the fuel bed and breaking up coke.

In plants equipped with underfeed stokers, not suitable for developing maximum capacity or economy with lignite alone, mixtures of lignite and coking coal are being burned at higher efficiencies than could be obtained with either fuel alone, and at substantial reductions in the cost of steam. The proportions of the two coals vary with plant conditions but in every case best operation and lowest steam cost are obtained with mixtures in which the lignite predominates.

The use of lignite in industrial plants in Saskatchewan has been stimulated by the action of the provincial government in equipping the power and heating plants under its control in the southern part of the province to burn the native fuel. The economies effected have more than repaid the entire investment cost of the improvements.

The granting of subventions by the Dominion Government on coals mined in western Canada for shipment to industrial plants in eastern Manitoba and western Ontario, has resulted in the displacement of large tonnages of imported coals by Canadian coals, in which the Saskatchewan industry has participated. Present subventions are based on transportation cost and since Saskatchewan coal moves relatively shorter distances to market the per ton subsidy is less than for other fields.

Total shipments of Saskatchewan coal into Manitoba and Ontario increased from 230,929 tons in 1929, without government assistance, to 408,822 tons in 1935, an increase of 177,907 tons. Of this increase 138,584 tons moved under subventions ranging from fifteen cents per ton to thirty-five cents per ton, with an average for 1935 of twenty-three cents per ton. The average subvention paid on all Canadian coals in 1935 was ninety-four cents per ton. Increases in shipment of bituminous and sub-bituminous coals from other western provinces into the same territory were 147,285 tons less than the total shipments under subventions in 1935. Lignite shipments from Alberta to Manitoba and Ontario decreased 228,917 tons or 45.7 per cent in the same period.

### Recent Trends in Development of Production Plants

The lignite area is divided naturally into two producing fields, viz.,

1. A field in the south-western part of the province in which smaller deposits are mined for local use. Production in this field in 1936 was approximately 10 per cent of the total.
2. A field at the eastern end of the area, served by both railroads, from which practically all of the coal shipped by rail or commercial truck is produced. Production from this field in 1936 was approximately 90 per cent of the total.

**Fig. 5—Loading Lignite into 4-ton pit Cars at Opencast Mine.**

Prior to 1930 about 90 per cent of the total tonnage was produced by six underground mines. Production from these mines in 1936 represented about 50 per cent of the increased total for the province. In 1930 a mechanized strip mine was opened, production from which accounted for the greater part of the increase in field output for two years. Since that time the increase has been taken up largely by smaller underground mines. The increase in production from these smaller mines has been made possible by an abnormal labour condition.

Of the present total field production, approximately 10 per cent is produced for local use in small operations, labour for which supplements employment on the farms or in other local industries; 25 per cent is produced by one fully mechanized strip mine having a minimum of seasonal fluctuation in employment; 50 per cent is produced by four underground mines having annual outputs from 60,000 to 200,000 tons each, with some power equipment; 15 per cent is produced from smaller operations without trackage facilities and dependent almost entirely on hand labour.

As the result of the findings of the Royal Commission which investigated labour conditions in the underground mines in 1931, operators of larger mines agreed to maintain prices at a level which would permit payment of a fair wage scale at the mines affected by the investigation. Operators of the small mines were not affected by the agreements nor did many of them come under the provisions of the Workmen's Compensation Act until after a second investigation in 1935 which resulted in legislation setting up a Provincial Coal Administration.

While the increase in production has provided part time employment for more than six hundred men during a period of economic stress, the trend of the development has not been conducive to a stable industry, from the standpoint of either mine operator or labourer.

The entry of these small mines into the more profitable domestic market has prevented increase in, and in some cases has reduced, shipments of these sizes from the larger and better equipped mines. Increased production from the larger mines has been limited chiefly to the lower priced industrial sizes, with a corresponding reduction in average realization per ton. The reduction of 18 per cent in average realization per ton since 1929 has been due in large part to the increased proportion of coal shipped to the industrial market.

For the purpose of this study the statistics for the more recently developed strip mining section of the industry have been deducted from the total to permit direct comparison of conditions prior to 1930 with those existing in 1935, following a substantial growth in production totals. Figures for capital employed in 1934 are used, as the total for 1935 is incomplete due to the temporary elimination of the capital for one of the larger mines not operating at the end of the year.

Total capital employed in the underground mines increased about 7 per cent between 1929 and 1934. Capital employed per ton of production decreased from $6.88 in 1929 to $6.48 in 1934, but increased from $4.02 to $4.53 per dollar of value due to decreased average realization per ton. The corresponding figures for the strip mining section for 1934 were $3.46 per ton and $2.95 per dollar of value. Comparative averages for Canada in 1929 and 1934 were respectively $8.11 and $8.57 per ton and $2.25 and $2.82 per dollar of value.

### Trends in Employment

As indicated above, average changes in the relation of capital invested to tonnage and value of production in the underground section of the industry were more favourable in Saskatchewan than in the other western provinces, or the average for the Dominion. The change in employment conditions constitutes a more serious danger to the building of a self-sustaining industrial community, without which any industry is of doubtful value.

Comparing production and employment figures for the underground mines for 1929 and 1935, production increased 19.4 per cent with an increase of 20.4 per cent in man days worked. Total value of production increased 3 per cent, with a decrease of 14.8 per cent in earnings of workers. Average realization per ton decreased 23 cents while labour cost decreased 26 cents.

The trend in employment with increasing production in the underground mines is shown in Table II below:—

Table II

| Month | Underground Mine Section | | | | | | Strip Mine Section | |
|---|---|---|---|---|---|---|---|---|
| | 1925–1926 | | 1928–1929 | | 1934–1935 | | 1934–1935 | |
| | No. of men | Av. days per man | No. of men | Av. days per man | No. of men | Av. days per man | No. of men | Av. days per man |
| June | 309 | 14.0 | 298 | 10.7 | 339 | 8.0 | 51 | 20.2 |
| July | 324 | 15.7 | 304 | 11.9 | 351 | 9.1 | 48 | 22.4 |
| August | 309 | 15.5 | 318 | 15.6 | 460 | 11 3 | 47 | 26.4 |
| September | 431 | 17.6 | 457 | 15.2 | 1,031 | 17.3 | 63 | 23.6 |
| October | 731 | 22.7 | 738 | 21.2 | 1,339 | 19.4 | 69 | 29.1 |
| November | 768 | 20.9 | 773 | 17.9 | 1,254 | 17.5 | 65 | 25.4 |
| December | 727 | 17.0 | 719 | 15.6 | 1,158 | 19.3 | 67 | 25.2 |
| January | 650 | 16.3 | 711 | 19.8 | 1,084 | 20.2 | 68 | 29.4 |
| February | 614 | 14.7 | 691 | 17.6 | 946 | 13.3 | 62 | 19.1 |
| March | 537 | 16.1 | 592 | 15.1 | 777 | 14.6 | 57 | 20.5 |
| April | 366 | 13.4 | 413 | 22.7 | 505 | 13.1 | 51 | 21.6 |
| May | 336 | 13.9 | 373 | 17 4 | 397 | 10.6 | 46 | 20.9 |
| | | 197.8 | | 200.7 | | 173.7 | | 283.8 |
| Maximum men | 768 | | 773 | | 1,339 | | 69 | |
| Minimum men | 309 | | 298 | | 339 | | 46 | |
| Ratio—max.-min. | 2.48 | | 2.59 | | 3.96 | | 1.5 | |
| Average earnings per man per day | $4.39 | | $4.46 | | $2.96 | | $4.18 | |
| Tons per man day | 4.34 | | 4.65 | | 4.45 | | 14.2 | |
| Tons produced | 453,732 | | 513,843 | | 694,544 | | 235,685 | |

Table III shows the effect of seasonal production on earnings per man per year. Increase in the seasonal range and dispersal of production among a greater number of smaller operations have both acted to spread employment over a greater number of men and to decrease the employment available to each man. It will be noted that as production has increased, the percentage of the total men working in all twelve months of the year has decreased and the number of man-days worked by this group has shown a slight progressive decrease over the ten-year period. The trend is shown graphically in Fig. 6.

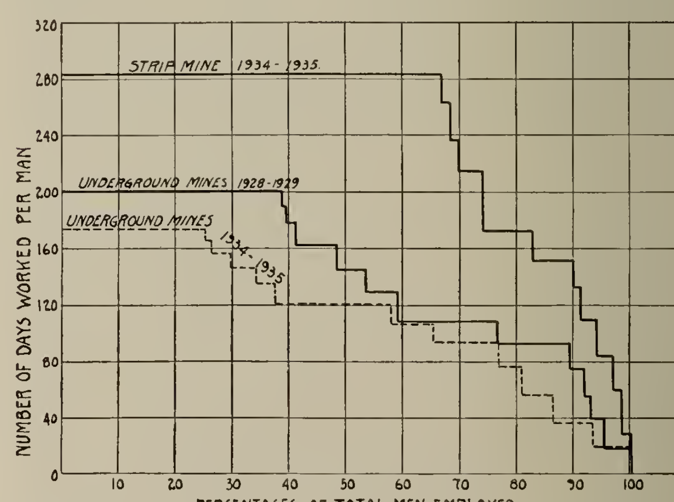


Fig. 6—Employment in Underground and in Strip Mines.

### Stabilization Methods

A Royal Commission was appointed in 1934 to investigate the lignite industry as a result of threatened labour

Table III

Underground Mine Section

| No. of months worked | 1925–1926 | | | | 1928–1929 | | | | 1934–1935 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of men | Per cent of max. number | No. of days | Annual earnings | No. of men | Per cent of max. number | No. of days | Annual earnings | No. of men | Per cent of max. number | No. of days | Annual earnings |
| 12 | 309 | 40.3 | 197.8 | $868 | 298 | 38.6 | 200.7 | $895 | 339 | 25.3 | 173.7 | $515 |
| 11 | | | | | 6 | 0.8 | 190.0 | 848 | 12 | 0.9 | 165.7 | 491 |
| 10 | 15 | 2.0 | 168.3 | 739 | 14 | 1.8 | 178.1 | 795 | 46 | 3.4 | 156.6 | 464 |
| 9 | 11 | 1.4 | 152.6 | 670 | 55 | 7.1 | 162.5 | 726 | 63 | 4.7 | 146.0 | 432 |
| 8 | 31 | 4.0 | 138.7 | 609 | 40 | 5.2 | 145.1 | 648 | 45 | 3.3 | 134.7 | 399 |
| 7 | 65 | 8.5 | 125.3 | 551 | 44 | 5.7 | 122.4 | 546 | 272 | 20.3 | 121.6 | 360 |
| 6 | 106 | 13.8 | 107.7 | 473 | 135 | 17.4 | 108.2 | 484 | 169 | 12.6 | 107.0 | 317 |
| 5 | 77 | 10.0 | 91.6 | 402 | 99 | 12.8 | 92.1 | 410 | 85 | 6.4 | 93.7 | 277 |
| 4 | 36 | 4.7 | 76.9 | 337 | 20 | 2.6 | 74.5 | 332 | 53 | 4.0 | 76.4 | 226 |
| 3 | 63 | 8.2 | 60.6 | 266 | 8 | 1.0 | 54.7 | 244 | 74 | 5.5 | 56.2 | 166 |
| 2 | 14 | 1.9 | 37.9 | 166 | 19 | 2.5 | 39.1 | 174 | 96 | 7.2 | 36.9 | 108 |
| 1 | 41 | 5.2 | 20.9 | 92 | 35 | 4.5 | 17.9 | 80 | 85 | 6.4 | 19.4 | 57 |
| Total | 768 | 100.0 | | | 773 | 100.0 | | | 1,339 | 100.0 | | |

disturbances at some of the larger underground mines. Following the submission of the report of the Commission the Saskatchewan Coal Mining Industry Act was enacted in 1935.

By virtue of this legislation the provincial government exercises supervision over wage schedules, and payment of wages, rentals due to the Crown, royalties on coal mined on Crown lands, and Workmen's Compensation assessments. The Lieutenant Governor in Council is authorized "to give force and effect to agreements between groups or associations of operators approved by the minister (of Natural Resources) for stabilizing of conditions in the coal mining industry of Saskatchewan which will ensure fair wages to employees for their labour, fair returns to operators on their investment and fair value to consumers in the form of a more uniform and standardized product. Such agreements may provide for:—

(*a*) minimum prices at the minehead in Saskatchewan for the different grades and sizes of coal;

(*b*) standards of grades and sizes upon which such minimum prices shall be based; and

(*c*) conditions under which such minimum prices shall be observed and maintained."

All mines are operated under licenses issued by the Coal Administrator.

The Act provides machinery for correcting such abuses as were indicated by evidence submitted to the Commission. Other evidence submitted indicated that annual earnings of the men were inadequate on account of short time employment. In the report of the Commission, Mr. Justice Turgeon quoted the following from evidence submitted:—"A large number of the men employed in and about the mines are unable to support themselves and their families while working and practically all of the men are unable to support themselves and their families when laid off or only working part time; and these men and families require to be assisted by their respective municipalities under such conditions;"

With respect to employment, Mr. Justice Turgeon stated "Insofar as these men are concerned the general attitude in respect to wages is not that the schedules of wages are too low, but that the number of working days in the year are too few to allow them to make a fair annual living wage."

Enforcement of the Act can provide increased daily earnings and improved conditions of employment at mines where adequate wages were not paid and where safe working places were not provided. No statistics are available covering employment and earnings since the Act has been in force by which its effectiveness can be measured. It will be evident from the previous comparative employment data that a return to the higher wage schedules of 1929 would not provide an adequate annual income for many of the additional part time workers employed in recent years as a result of increased seasonal production.

No practical method of reducing the seasonal range of production appears possible at this time. Continued increase in production can be expected to further increase the seasonal range of employment. The situation has been aggravated by the general depression and local crop failures, preventing men from obtaining supplementary employment in other industries. It is apparent that a self-sustaining industrial community cannot be maintained under the scale of employment and average earnings indicated by the employment data. The comparative records of recent years indicate that reduction in the proportion of short time employment and increased average earnings require the adoption of production methods less dependent upon hand labour.

The record of development in the lignite mining industry of the adjoining state of North Dakota, in which all physical factors are directly comparable with those in Saskatchewan, shows an increase in the proportion of total production coming from strip mines and an increasing production per man per year in both strip and underground mines due to the use of an increasing amount of

Table IIIA

Strip Mine Section

| Number of months worked | 1934-1935 | | | |
|---|---|---|---|---|
| | Number of men | Per cent of max. number | Number of days | Annual earnings |
| 12 | 46 | 66.7 | 283.8 | $1,185 |
| 11 | 1 | 1.4 | 262.9 | 1,098 |
| 10 | 1 | 1.5 | 236.5 | 989 |
| 9 | 3 | 4.3 | 214.1 | 895 |
| 8 | | | | |
| 7 | 6 | 8.7 | 172.3 | 720 |
| 6 | 5 | 7.3 | 151.8 | 635 |
| 5 | 1 | 1.4 | 132.7 | 555 |
| 4 | 2 | 2.9 | 109.1 | 457 |
| 3 | 2 | 2.9 | 83.7 | 350 |
| 2 | 1 | 1.5 | 58.5 | 244 |
| 1 | 1 | 1.4 | 29.1 | 122 |
| Total | 69 | 100.0 | | |

power equipment. Detailed data of employment and earnings are not available, the records showing only the maximum number of men employed in each mine. The trend of development over a fourteen-year period is shown in Table IV.

Table IV

Production Statistics for the North Dakota Lignite Industry

| | 1922 | 1929 | 1935 |
|---|---|---|---|
| Total production, tons | 1,057,823 | 1,902,593 | 1,828,213 |
| Value of production, dollars | 2,616,802 | 3,473,658 | 2,385,229 |
| A—Local mines producing less than 5,000 tons per year: | | | |
| Number reporting | 78 | 185 | 320 |
| Tons produced | 236,766 | 214,368 | 242,849 |
| Per cent of total field output produced | 18.0 | 11.2 | 13.0 |
| B—Mines producing more than 5,000 tons per year: | | | |
| Number of strip mines | 6 | 6 | 11 |
| Number of underground mines | 33 | 22 | 26 |
| Output of strip mines, tons | 186,500 | 837,267 | 1,004,045 |
| Output of underground mines | 741,123 | 850,958 | 581,319 |
| Per cent of total field output: | | | |
| From strip mines | 12.5 | 43.9 | 55 |
| From underground mines | 69.5 | 44.9 | 32 |
| Maximum number of men employed in mines producing more than 5,000 tons per year: | | | |
| Strip mines | 297 | 805 | 560 |
| Underground mines | 1,196 | 1,088 | 585 |

Trends in production per man per year, based on the maximum number of men employed, for North Dakota and Saskatchewan, are shown in Table V. The figures for North Dakota include only mines producing more than 5,000 tons per year; figures for Saskatchewan include all mines. Production from mines having annual outputs less than 5,000 tons were 3.4 per cent in 1922, 6.5 per cent in 1929, and 10.2 per cent in 1935, of the totals for underground mines only.

Table V

Comparative Production per Man per Year

| | 1922 | 1929 | 1935 |
|---|---|---|---|
| North Dakota: | | | |
| Strip mines | 628 | 1,040 | 1,790* |
| Underground mines | 620 | 728 | 993† |
| Saskatchewan: | | | |
| Strip mine | | | 3,320 |
| Underground mines | 597 | 788 | 575 |

*Maximum: 2,970 tons. †Maximum: 1,600 tons.

Comparative values of the coal produced in North Dakota and Saskatchewan are shown in Table VI.

Table VI

Comparative Per Ton Values of Coal Produced (All Mines)

| | 1922 | 1929 | 1935 |
|---|---|---|---|
| North Dakota | $2.46 | $1.83 | $1 30 |
| Saskatchewan | 2.10 | 1.71 | 1.40 |

Comparative statistics for the underground mine and strip mine sections of the Saskatchewan industry show that the basic requirements of minimum capital investment in relation to production value, combined with minimum seasonal fluctuations in employment, are best met by the mechanized strip method. Some increase in mechanization has been effec ed in the larger underground mines during the period under review, but the effect on employment in these mines has been masked by the disproportionate increase in the use of hand labour in the smaller mines. While strip methods are not applicable in all cases, production records indicate mechanization in underground operations has increased production per man per day, in some instances to a point comparable with average strip mine production.

Summary

Social legislation provides protection for the workers during the time they are employed. The present need is for greater continuity of employment. The interests of the workers and of the community can be best served by the adoption of production methods which provide the maximum number of days work for a smaller number of men rather than by distribution of a greater total number of days work among such a large number of men that the combined total earnings are inadequate to maintain a reasonable standard of living for the whole community.

Fig. 7—Tipple at Truax-Traer Opencast Mine, showing Rotary Pump (left) and Pneumatic Cleaning Plant (right).

Such production methods, calling for an increased use of power equipment, require the concentration of commercial production into a smaller number of adequately equipped mines with minimum overall costs, and the elimination of unsafe and uneconomical operations.

Provision for adequate annual earnings for the maximum proportion of the men employed, which is essential to the development and maintenance of a self-sustaining industrial community, under existing natural limitations of the industry, is a problem calling for solution by the managements of the several mine operations.

The experience of the past seven years indicates that stabilization of the industry to ensure fair wages to the employees for their labour, fair returns to the operators on their investments and fair value to the consumers, can best be effected, during the present formative stages of development of the commercial section of the industry, by (1) voluntary co-operation between the managements of the several operations in the formulation of a sound policy of development, (2) consolidation of management and of production facilities into units large enough to permit efficient and economical use of power equipment, and (3) maintenance of mine prices at levels which will permit payment of fair wage schedules and fair returns on efficient operations, but which will not encourage the development of unsafe or uneconomical operations dependent upon abnormal labour conditions for their existence.

Physical conditions affecting production and geographical position of the field in relation to markets are sufficiently favourable to permit continued development and growth of an economically sound industry serving alike the interests of the workers, the operators and the consuming public.

# Experience in Burning Western Canadian Coals

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

**SUMMARY.**—Describes the original boiler and furnace equipment and that later installed in the Regina city power plant, discussing the operating difficulties and the results obtained with underfeed stokers and pulverized fuel when burning Alberta bituminous coals and Saskatchewan and Alberta lignites.

In giving results of burning Western fuels in the Regina city power plant, it is best to outline conditions generally.

Regina's geographical location is far from any reliable water power site, but as a compensating feature is in the competitive centre of several coal fields, being 125 miles from the lignite fields in the south eastern part of Saskatchewan; some 600 miles from the Crow's Nest field of bituminous coal in Alberta and about 500 miles from the Drumheller lignite fields in Alberta, with some of the Edmonton district coal being competitive at times.

All four fields have by-product coal of extremely fine size, which is the present class of coal burned in the Regina city plant in pulverized form.

This competitive condition of by-product fuel has not always prevailed, for at the time of design of the present plant in 1913, the then outstanding value in fuel was the bituminous coal from the Crow's Nest field in Alberta. Consequently the stokers selected for the plant were the incline underfeed type with moving side bars of retorts, which stokers at that time and even yet, are eminently suitable for burning reasonably low ash and slightly coking bituminous coal.

### Original Equipment

The present power house, located on the shore of Wascana lake, is the second power plant built by the city and followed an earlier plant built in 1904 on a site without liberal circulating water supply, power demands on which soon expanded beyond the cooling pond capacity. Rather than be tied to cooling towers and poor vacuum for the steam turbines, then the outstanding prime mover, a new site close to a large body of water was selected.

The plant was designed on the bus system, in that the building was arranged with turbine room and boiler room with their lengths parallel, with circulating pumps, boiler feed pumps, and induced draft fans and stack located at the adjacent ends of the two rooms.

The boiler room was arranged for two rows of boilers facing on a firing aisle, over which were coal bunkers of 1,500 tons capacity with eight separate coal pockets and outlets for each boiler of the original design of sixteen boilers, although only the row of boilers next to turbine room was developed on this plan.

The Babcock-Wilcox boilers with longitudinal drums in 500-hp. units were arranged in batteries of two boilers each with a six foot space between batteries with four batteries on each side of firing aisle occupying a panel of 28 ft. 6 in. each battery. Each boiler has a feed water section of 160, 12-ft. cast iron economizer tubes set in the same setting.

The boiler room floor is set 14 ft. above the basement floor and the space between is utilized for ash hoppers, air chamber for stokers and ash removal equipment, with a gas flue running below the boiler room floor with gas damper in passage from each boiler, as in Fig. 1, which shows the whole plant as planned in 1913.

The gas flues next to the building wall lead to induced draft fans at the end of the boiler room, with additional dampers making it possible to have gases flow direct to fans or through gas passages and a group of 320 standard 9-ft. tube economizers on way to the induced draft fan suction. This economizer group was operated with no pressure, but with condensate flowing through on the inverted siphon principle on the way from the condensate pumps to the open feed water heater, into which heater all feed pump and fan driving engines exhaust was directed.

The 160 economizer tubes acting as a feed water section of each boiler were all set in line with the under floor gas passages, and additional dampers so arranged that the feed water sections of idle boilers could be made to be included

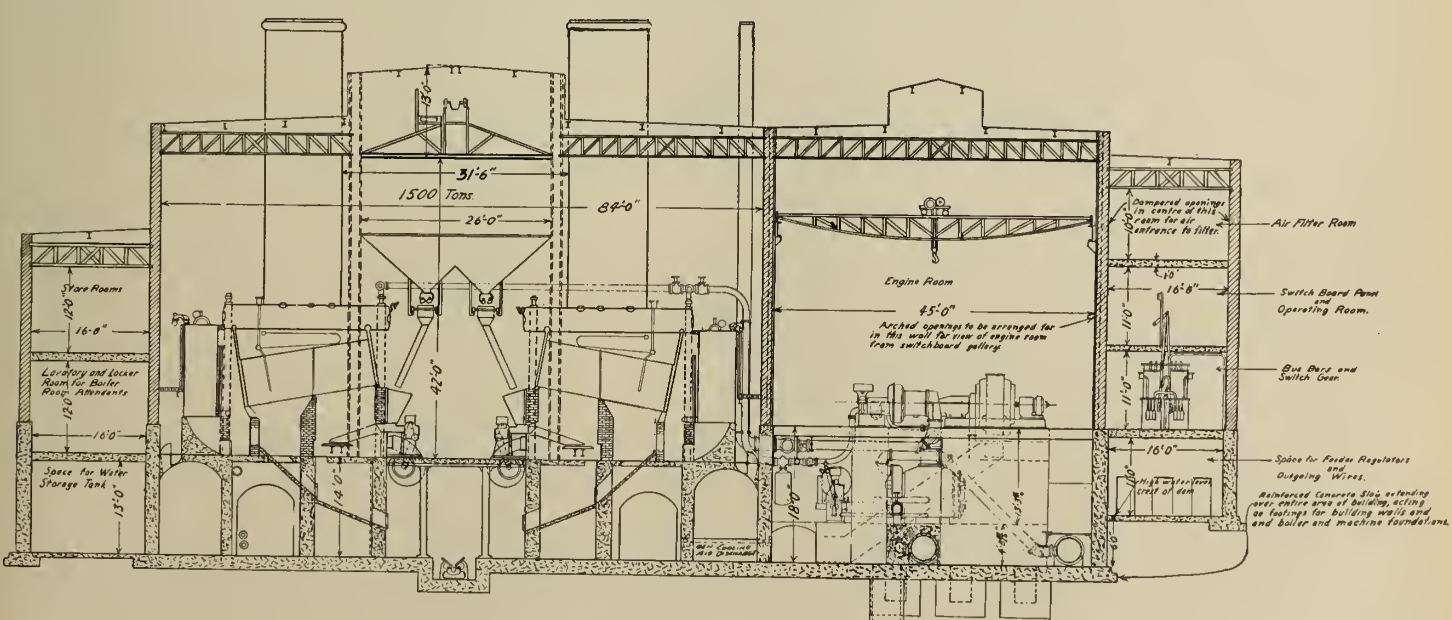


**Fig. 1—Arrangement of Equipment for Regina City Power Plant.**

## Table I

### Boiler Trials, 1922

| | | 1 | 2 | 3 | 9 | 11 | 12 | 4 | 13 | 5 | 6 | 7 | 8 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Test of one 500 hp. B. & W. boiler, 220-4 in. tubes | | | | | | | | | | | | | |
| 2 | One Riley 7 retort long stoker and 160-12 ft tubes economizer | | | | | | | | | | | | | |
| 3 | Grate surface.....sq. ft. | 132 | 132 | 132 | 132 | 132 | 132 | 132 | 132 | 132 | 132 | 132 | 132 | 132 |
| 4 | Water heating surface—total boiler and economizer.....sq. ft. | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 | 6,848 |
| 5 | Superheater surface.....sq. ft. | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 |
| 6 | Date of trial | Sept.22-24 | Sept.26-28 | Sept.29-30 | Oct. 20-22 | Oct. 27-29 | Nov. 1-3 | Oct. 3-5 | Nov. 4-5 | Oct. 6-8 | Oct. 10-12 | Oct. 13-15 | Oct. 17-19 | Oct. 24-26 |
| 7 | Duration of trial.....hr. | 44 | 48 | 24 | 48 | 48 | 48 | 48 | 24 | 48 | 48 | 48 | 48 | 48 |
| | | Bienfait mine | Bienfait commercial | Crescent lignite | Lethbridge | Atlas nut slack | Newcastle nut slack | Crows Nest | Crows Nest | McGillivray Creek | Corbin | Durham slack and slacky mine run | Greenhill | McGillivray |
| 8 | Kind of Coal | High moisture lignites Saskatchewan field | | | Low moisture lignites Drumheller | | | Bituminous—Crows Nest field | | | | | | |
| | **Average Pressure, Temperature, Etc.** | | | | | | | | | | | | | |
| 9 | Steam pressure by gauge.....lb. | 195.6 | 196.6 | 196.7 | 195.6 | 197.0 | 198.0 | 195.3 | 197.6 | 195 | 197.2 | 196.25 | 198.1 | 198.0 |
| 10 | Draft in stoker pressure chamber.....in. of water | 1.30 | 1.02 | 1.48 | 1.12 | 1.2 | 1.23 | 1.58 | 1.28 | 2.74 | 2.46 | 2.64 | 2.36 | 2.60 |
| 11 | Draft suction over fire.....in. of water | 0.088 | 0.033 | 0.037 | 0.15 | 0.036 | 0.065 | 0.0048 | 0.0043 | 0.04 | 0.051 | 0.062 | 0.011 | 0.0136 |
| 12 | Draft suction main flue.....in. of water | 0.42 | 0.44 | 0.53 | 0.50 | 0 236 | 0.315 | 0.322 | 0.335 | 0.45 | 0.34 | 0.360 | 0.366 | 0.363 |
| 13 | Temperature of air in stoker pressure chamber.....deg. F. | 87.2 | 103.4 | 103.4 | 92.0 | 93.0 | 89.3 | 94.5 | 78.5 | 85.4 | 84.4 | 90.1 | 90.1 | 88.8 |
| 14 | Furnace temperature.....deg. C. | 1,310 | 1,280 | 1,210 | 1,350 | 1,440 | 1,380 | 1,450 | 1,500 | 1,460 | 1,480 | 1,460 | 1,510 | 1,490 |
| 15 | Temperature of flue gases.....deg. F. | 309 | 400 | 380 | 415 | 388 | 386 | 371 | 384 | 347 | 342 | 339 | 349 | 370 |
| 16 | Temperature of feed water.....deg. F. | 154 | 163 | 147 | 134 | 141 | 139 | 139 | 136 | 126 | 136 | 136 | 142 | 141 |
| 17 | Temperature of steam.....deg. F. | 501 | 510 | 538 | 549 | 558 | 588 | 552 | 577 | 552 | 550 | 549 | 550 | 543 |
| 18 | Carbon di-oxide in flue gases.....per cent | 10.8 | 12.3 | 8.9 | 7.5 | 9.5 | 8.5 | 12.5 | 10.8 | 11.35 | 12.7 | 10.7 | 10.1 | 10.6 |
| | **Particulars of Fuel** | | | | | | | | | | | | | |
| 19 | Moisture.....per cent | 34.4 | 34.1 | 27.2 | 8.54 | 17.92 | 17.2 | 1.32 | 1.7 | 1.54 | 3.56 | 1.78 | 1.70 | 1.86 |
| 20 | Ash-dry basis.....per cent | 10.8 | 10.5 | 24.6 | 17.25 | 10.33 | 13.86 | 7.08 | 5.50 | 14.3 | 15.48 | 15.33 | 13.67 | 14.47 |
| 21 | Ash in coal as fired.....per cent | 7.085 | 6.92 | 17.91 | 15.78 | 8.48 | 11.47 | 6.98 | 5.40 | 14.01 | 14 93 | 15.06 | 13.44 | 14.20 |
| 22 | B.t.u.—dry basis.....per lb. | 10,300 | 10,500 | 8,600 | 10,350 | 11,160 | 10,650 | 14,450 | 14,500 | 13,191 | 12,520 | 12,300 | 12,760 | 12,910 |
| 23 | B.t.u.—in coal as fired.....per lb. | 6,757 | 6,920 | 6,261 | 9,466 | 9,160 | 8,818 | 14,260 | 14,253 | 12,987 | 12,074 | 12,081 | 12,543 | 12,670 |
| | **Weights of Coal, Water and Ash** | | | | | | | | | | | | | |
| 24 | Total weight of coal fired.....lb. | 190,500 | 232,500 | 121,000 | 173,000 | 173,000 | 180,000 | 124,250 | 67,500 | 134,000 | 154,000 | 138,000 | 148,500 | 139,500 |
| 25 | Total weight of water evaporated.....lb. | 802,300 | 878,200 | 437,150 | 1,030,000 | 969,125 | 946,350 | 1,182,500 | 65,600 | 1,085,000 | 1,155,925 | 1,097,500 | 1,258,650 | 1,155,300 |
| 26 | Coal burned per hour, as fired.....lb. | 4,330 | 4,844 | 5,042 | 3,604 | 3,604 | 3,750 | 2,588 | 2,812 | 2,792 | 3,208 | 2,875 | 3,094 | 2,906 |
| 27 | Coal burned per hour, dry.....lb. | 2,840 | 3,192 | 3,670 | 3,296 | 2.958 | 3,105 | 2,554 | 2,765 | 2,749 | 3,094 | 2,824 | 3,041 | 2,852 |
| 28 | Coal burned per hour per sq. ft. of grate surface, as fired.....lb. | 32.8 | 36.7 | 38.2 | 27.3 | 27.3 | 28.4 | 19.6 | 21.3 | 21.15 | 24.3 | 21.8 | 23.4 | 22.0 |
| 29 | Coal consumed per retort, per hour.....lb. | 618.6 | 692.0 | 720.3 | 514.9 | 514.9 | 535.7 | 369.7 | 401.7 | 398.9 | 458.3 | 410.7 | 442.0 | 415.1 |
| 30 | Total weight of refuse.....lb. | 19,674 | 37,415 | 43,338 | 45,680 | 29,484 | 30,603 | 11,001 | 4,770 | 24,471 | 27,952 | 26,974 | 25,179 | 24,277 |
| 31 | Total weight of combustible burned.....lb. | 105,294 | 115,803 | 44,750 | 112,546 | 112,516 | 118,437 | 111,609 | 61,582 | 107,465 | 120,566 | 108,570 | 120,796 | 112,628 |
| | **Hourly Quantities and Rates** | | | | | | | | | | | | | |
| 32 | Water evaporated per hour.....lb. | 18,234 | 18,296 | 18,215 | 21,458 | 20,190 | 19,716 | 24,635 | 27,333 | 22,604 | 24,082 | 22,865 | 26,222 | 24,069 |
| 33 | Factor of evaporation | 1.1795 | 1.174 | 1.206 | 1.224 | 1.222 | 1.240 | 1.221 | 1.237 | 1.234 | 1.223 | 1.223 | 1.218 | 1.215 |
| 34 | Equiv. evaporation per hour from and at 212 deg. F.....lb. | 21,507 | 21,479 | 21,967 | 26,265 | 24,672 | 24,447 | 30,080 | 33,812 | 27,894 | 29,452 | 27,963 | 31,938 | 29,243 |
| 35 | Superheat in steam.....deg. F. | 115 | 124 | 152 | 163 | 171 | 201 | 166 | 190 | 166 | 163 | 163 | 163 | 156 |
| | **Evaporation** | | | | | | | | | | | | | |
| 36 | Water evaporated per lb. of coal as fired.....lb. | 4.21155 | 3.7772 | 3.6124 | 5.9537 | 5.6019 | 5.2575 | 9.5171 | 9.7185 | 8.0970 | 7.5060 | 7.9529 | 8.4758 | 8.2817 |
| 37 | Water evaporated per lb. of dry coal.....lb. | 6 4200 | 5.7317 | 4.9627 | 6.5097 | 6.8248 | 6.3496 | 9.6444 | 9.8866 | 8.2236 | 7.7831 | 8.0970 | 8.6224 | 8.4387 |
| 38 | Equiv. evaporation per lb. of coal as fired.....lb. | 4.9675 | 4.4344 | 4.3565 | 7.2873 | 6.8455 | 6.5193 | 11.6204 | 12.0218 | 9.9917 | 9.1798 | 9.7264 | 10.3235 | 10.0623 |
| 39 | Equiv. evaporation per lb. of dry coal.....lb. | 7.5724 | 6,7290 | 5.9849 | 7.9678 | 8.3399 | 7.8735 | 11.7758 | 12.2298 | 10.1480 | 9.5187 | 9.9026 | 10.5020 | 10.2530 |
| 40 | Equiv. evaporation per lb. of combustible burned.....lb. | 8.4893 | 7.5185 | 7.9368 | 9.6291 | 9.3009 | 9.1396 | 12.6722 | 12.9406 | 11.8315 | 11.2622 | 11.6960 | 12.1653 | 11.9875 |
| 41 | Equiv. evaporation per sq ft. of heating surface per hour.....lb. | 3.1406 | 3.1365 | 3.2078 | 3.8354 | 3.6028 | 3.5699 | 4.3925 | 4.938 | 4.0733 | 4.3008 | 4.0834 | 4.6638 | 4.2703 |
| 42 | Combined efficiency.....per cent | 71.3 | 62.2 | 67.5 | 74.7 | 72.4 | 71.7 | 79.1 | 81.8 | 74.6 | 73.8 | 78.1 | 79.8 | 77.1 |

in a gas passage parallel to the main under the floor flue, thus making it possible to bring the greatest amount of economizer surface in service with gases passing on way to induced fan and stack, and feed water directed in contraflow on its way to the active and more efficient boilers furthest away from fans and stack which were always operated as base load equipment.

With this arrangement of equipment with a complete building provided for two rows of eight 500 hp. boilers and six turbines, installations were made as load conditions required, both in boilers and turbines, each new installation successively occupying the next vacant space nearest to the fans, circulating pump and feed pumps at one end of the building.

By 1914, four 500-hp. boilers and three turbines, aggregating 6,000 kw., had been installed.

Load increase continued despite the war conditions and in 1921 boilers 5 and 6 were installed. In order to try out the possibilities of burning the local Saskatchewan lignite, the stokers were increased to seven retorts wide and a longer type of stoker installed with a total of 132 sq. ft. of grate surface, whereas the original short stokers were six retorts wide with only 82 sq. ft. grate surface.

The water cooled ash pits were then placed in service, all as shown in Fig. 2.

In order to assist in burning the high moisture lignite, a form of arch was placed to join up the new bridge wall located for the long stoker and the regular vertical baffle that was immediately above the original bridge wall when the short stokers were in use. This flat arch was supported by an air-cooled box girder and gave satisfaction in burning the high moisture lignite by its reflecting power concentrated at the proper section of the fuel bed.

When the lignite, due to price variation, ceased to be the best fuel, low ash bituminous coals were burned with complete success on the same equipment up to reasonable rates of burning on the grate. Eventually the bridge wall was rearranged and continued upwards to a point near the lower boiler tubes and a tile baffle placed above the lower row of tubes to connect the bridge wall with the original vertical boiler baffle was constructed, as shown by dotted lines in Fig. 2.

With the removal of the reflecting arch, burning of even bituminous coal was not so good at light loads.

The side wall surfaces at the fuel bed line was severely punished whenever high ratings had to be taken from the boilers.

The answer to this condition, was to install Carbofrax bricks on the hot zone of the furnace at side walls to a point above the regular height of fuel bed.

### Principles Involved in Burning Coal on Stokers

In operating highly forced draft underfeed stokers a closed ash pit is required, which in this case evolved from a brick lined concrete pit into a closed water-cooled ash pit of fire box construction with properly arranged doors to drop ash to a drag chain conveyor.

It was early found that the capacity limiting feature of underfeed stoker operation was the discharge of the ash without allowing too much burning coke to discharge in quantities, which would not only result in a loss of heat by reason of the carbon not being consumed in the furnace, but would cause the ash pit to act as a gas producer when leakage of air from the forced draft plenum chamber filtered through the racks required for adjustment of the ash discharge section of the Riley underfeed stokers. Under certain conditions the smallest opening from the ash pit was a liability, and tongues of blue flame would come from every leak around ash pit doors.

As a result of these experiences, in an effort to protect the equipment, the ash pit was vented to the furnace side above the fuel bed to convey any combustible gases along with the air leakage to the furnace, as shown in Fig. 2.

This condition of burning prevailed during the tests made in 1922 and 1925–26, results of which are shown in Tables I and II.

The cooling of the ash pit and stoker discharge backing box by condensate was a regular operating condition, and the heat absorption of the cooled ash pits figured in the efficiency obtained, as shown in Table II, when the whole boiler plant was tested to determine operating efficiency.

The principles of burning coal on underfeed stokers are well known, in that the volatile constituents of the fuel are distilled below the surface of the fuel bed and are

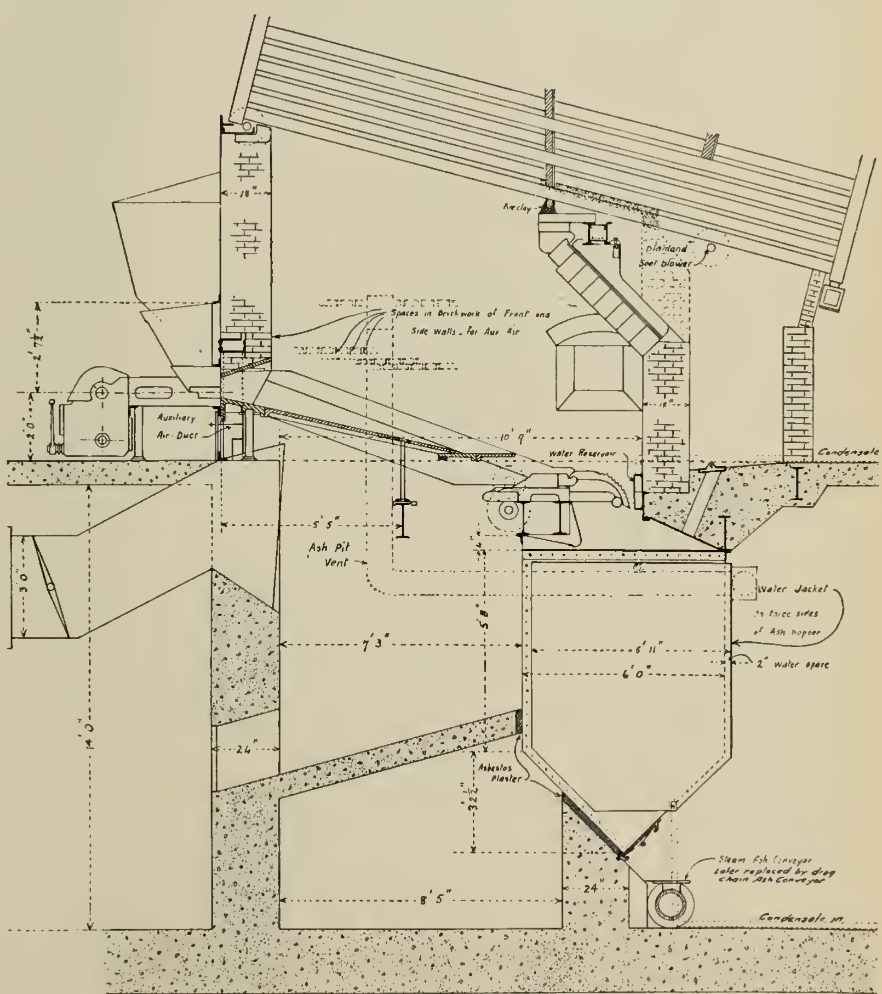


**Fig. 2—Stoker Arrangement for Boilers 5 and 6.**

thoroughly heated and mixed with the air as it passes through the spaces between the coal of fuel bed on the way to the finishing combustion spaces above the fuel bed.

In this system (or any grate system with a forced draft) of burning, the combustion air and expanded gases in their rush through the coal spaces carry with them small particles that are thrown off the coal pieces by spalling due to heat.

Table II
Summary of Coal Tests
Complete Plant Operation, 1925-6

| | | | | |
|---|---|---|---|---|
| 1 | Test of coal on Riley underfeed stokers installed under B. & W. boilers. | | | |
| 2 | Two Riley 7 retort long stokers, and one 6 retort stoker three-500 hp. B. & W. boilers. | | | |
| 3 | Grate surface 2 × 132 sq. ft. and 1 × 82 sq. ft | 346 | 346 | 346 |
| 4 | Water heating surface—3 × 4928.........sq. ft. | 14,784 | 14,784 | 14,784 |
| 5 | Superheating surface—1 × 1,400 and 2 × 720 sq. ft. | 2,840 | 2,840 | 2,840 |
| 6 | Economizer surface—6 × 1,920............sq. ft. | 11,520 | 11,520 | 11,520 |
| 7 | Ash pit heating surface—2 × 230...........sq. ft. | 460 | 460 | 460 |
| 8 | Low pressure economizer surface...........sq. ft. | 4,400 | 4,400 | 4,400 |
| 9 | Date of test.......................................... | Jan. 11-14<br>Feb. 1-4 | Dec. 29-Jan. 1<br>Jan. 25-28 | Jan. 5-8 |
| 10 | Duration of test............................hr. | 144 | 144 | 72 |
| | | Crows Nest | Greenhill | Corbin |
| 11 | Kind of coal.................................. | Bituminous Crows Nest field | | |
| | **Particulars of Operation** | | | |
| 12 | Hours operating of both 7 retort long stokers...hr. | 144 | 144 | 72 |
| 13 | Hours operating of short 6 retort stoker......hr. | 8.5 | 21.25 | 9.25 |
| | **Average Pressure, Temperature, Etc.** | | | |
| 14 | Steam pressure by gauge...........lb. per sq. in. | 198.5 | 196 | 198 |
| 15 | Pressure of air to stoker pressure chamber..........................in. of $H_2O$ | 0.537 | 0.995 | 1.04 |
| 16 | Main flue draft.....................in. of $H_2O$ | −0.525 | −0.476 | −0.525 |
| 17 | Temperature of air to stoker pressure chamber..............................deg. F. | 65 | 62.7 | 61 |
| 18 | Temperature of gases leaving boiler........deg. F. | 522.5 | 539.5 | 539 |
| 19 | Temperature of gases entering stack.......deg. F. | 189.5 | 203 | 202 |
| 20 | Temperature of steam by thermometer.....deg. F. | 534 | 537 | 538 |
| 21 | Temperature of feed water................deg. F. | 84.25 | 83.5 | 82 |
| 22 | Carbon dioxide ($CO_2$) in gases..........per cent | 8.925 | 8.395 | 8.41 |
| | **Total Quantities** | | | |
| 23 | Moisture in coal as received...........per cent | 1.48 | 1.81 | 3.42 |
| 24 | Ash in coal as received.................per cent | 6.515 | 14.56 | 17.20 |
| 25 | B.t.u. in coal as received........................ | 14,095 | 12,642 | 11,980 |
| 26 | Total weight of coal burnt..................lb. | 590,903 | 677,027 | 374,247 |
| 27 | Total feed water to boilers..................lb. | 5,356,212 | 5,275,313 | 2,724,300 |
| 28 | Net B.t.u. given to each lb. of feed water........ | 1225.9 | 1228.1 | 1230.9 |
| 29 | Combustible in ash pit refuse..........per cent | 26.83 | 19.72 | 24.33 |
| 30 | Total ash pit refuse.........................lb. | 53,150 | 123,400 | 85,920 |
| 31 | Factor of evaporation............................ | 1.2633 | 1.2653 | 1.2680 |
| 32 | Superheat in steam......................deg. F. | 147 | 150 | 151 |
| | **Evaporation** | | | |
| 33 | Water evaporated per lb. of coal as fired.......lb. | 9.0756 | 7.7919 | 7.2792 |
| 34 | Equivalent evaporation per lb. of coal as fired..lb. | 11.4650 | 9.8591 | 9.2300 |
| 35 | Efficiency of boiler plant...............per cent | 78.9 | 75.65 | 74.7 |

These particles, consisting of carbon, in size approximately 1/50th to 1/100th of an inch in diameter, are carried above the fuel bed and between the boiler tubes and, if considerable furnace volume is not available for combustion, are eventually cooled below combustion temperature.

With longitudinal drum Babcock and Wilcox boilers in 500-hp. units set eleven feet above fire floor, allowing a furnace depth between fuel bed and lower boiler tubes of six feet, it was found that with some coals, enough particles were carried over to require considerable handling of second pass and flue accumulation.

Analysis of these accumulations showed a high carbon content, running as high as 70 per cent combustible with certain coals.

The method of recovery was by extracting this accumulation from flues and boiler passes with screw conveyors, returning this extracted material to the coal being fed to the stoker, thus again passing the particles through the fuel bed.

While lignite was burned on the underfeed stokers in considerable quantities, its low heat value and the low melting point of the ash did not make for success. Any forcing to high rating of grate surface burning not only caused slagging of grate tuyeres, but fine particles of the low melting point ash were projected into the banks of tubes six feet above, eventually causing clogging of spaces between tubes by gradually building a collar or sleeve around each tube.

Despite efforts made to locate soot blowers to prevent this accumulation, this condition required that at intervals the boilers and furnace be laid idle and cooled for mechanical cleaning by men with lances working from the furnace space.

The results obtained, as shown on Table I, did not warrant continuing burning lignite with the underfeed stokers except when purchasable at a very low price.

The bituminous coal was considered best for the existing conditions so that prices were obtained competitively from time to time and tests made to determine the best fuel to purchase.

A series of tests of coal to operate the complete plant including banked boilers and based on using the complete equipment of economizers was made. The results of long period tests of three bituminous coals made early in 1926 are shown on Table II, from which may be noted the effect of a great area of brick walls of gas passage and economizer scraper openings in the low percentage of $CO_2$ registered. This low $CO_2$ was partly due to banking the fires for considerable periods, a procedure made necessary by the cyclic variations in load demand.

In 1926 the complete year's operation of the plant while burning Crow's Nest coal (the first of the tests in Table II) resulted in a coal consumption of 1.375 lb. per kw.h. generated with an average load on the turbo-generators of 55 per cent of their capacity.

This year's operation showed probably the best result obtained from the 200-lb. pressure plant operated with a great extent of economizer surface. Even before this date the regenerative cycle of feed heating was fast proving its worth and in 1924 when an additional turbine of 5,000 kw. capacity was purchased, the specifications called for its design for ultimately operating with 400 lb. pressure with a steam temperature of 750 deg. F. and for regenerative feed water heating with two points of extraction.

### Fuel Characteristics

In considering the fuel characteristics, it was found that the lightly coking bituminous coals from the Crow's Nest field in Alberta, with ash melting point from 2,300 to 2,700 deg. F., were well adapted to the underfeed stoker installation, which has moving tuyeres on retort sides within the furnace with adjustable lengthwise movement to allow of breaking up any coke that may form and keep the deep fuel bed free by constant movement of its coal lumps.

The only serious variation in these bituminous coals was in the percentage of ash, and in the melting point and constituents of the ash. Operation with a standard of 20 per cent carbon in ash pit refuse is feasible under good operating conditions. On this basis it is apparent that for each ton burned, coal that contains 15 per cent ash will discharge at least twice as much unburned carbon to the pit as a coal with 7.5 per cent ash, assuming the same excellence of separation at the ash discharge point of the stoker.

This proportion cannot be realized with high-ash coal, as the efficiency of ash and coke separation is really a function of the amount of refuse discharged in a given time from a definite volume of discharge space. The results establish that the low-ash coals, all other characteristics being equal, are definitely better coals to operate with.

There are other important characteristics besides the melting point of the ash. The ash composition may be such as will have a fluxing action on refractory lining of furnace, or again the ash may melt and run together in large clinkers. Other coals have ash that forms clinkers in lumps of walnut or golf ball size that do not adhere strongly to each other, consequently the discharge of clinkers is more readily effected.

In the original installation, as in Fig. 2, the ash discharge space did not have the benefit of the deep ash pit discharge pockets with rotary clinker grinders which were used in many underfeed stoker installations made at a later date. Nevertheless reasonable success was attained and the 1926 year's consumption of coal per kilowatt hour is evidence of this.

### Stoker Fired Lignite Characteristics

While the best success was with bituminous coals, there were times when price conditions made it advisable to burn lignites, whose operating characteristics varied considerably. In the original plant, without preheated air and with a high moisture content reducing the furnace temperature, lignites were successfully burned up to moderate rates of combustion without undue clinkering.

All the fuels were of the slack variety and on underfeed stokers behaved fairly well, but on occasion some of the fine free burning lignite ran in the stoker retorts like sand, with a considerable loss to the ash pit, as evidenced by the high percentage of combustible in the ash pit refuse, as shown on the 1922 tests of the lignite coals.

It is quite evident that the underfeed stoker is not the best equipment to burn fine size lignite and it appears that the travelling grate stoker with preheated forced draft is the logical equipment for burning such fuel if conditions are such that grates must be used.

### Pulverized Coal Equipment

When additional boiler capacity was required in 1927, burning of pulverized coal was fast coming to the fore. A study of the relative costs and efficiencies of stoker and pulverized fuel systems resulted in pulverizing equipment being purchased and installed in lieu of stokers for two of the 500-hp. boiler units already on hand. These were raised to secure sufficient furnace volume, and complete furnace wall cooling of the resulting 3,600 cu. ft. furnaces was applied to the installation by regular four-inch boiler tubes set behind the face of refractory tiles, which together with water tubes were applied to the walls as a separate nine-inch furnace lining.

These two boilers continued to operate with 200-lb. pressure and liberal economizer surface until 1930, when a new large steam generating unit for pulverized coal with no economizers, but with air preheater, operating at 430-lb. pressure and 750 deg. F. steam temperature, was purchased, together with a 15,000-kw. turbine. Extraction and deaerating heaters were provided for three points of extraction for feed heating for complete operation on the regenerative cycle, this new high-pressure section of the plant starting operation early in 1932.

In installing larger high-pressure steam generating units, the space in the boiler room formerly laid out for eight 500-hp. boilers was used, each steam generator occupying a panel that had been provided for a battery of two 500-hp. units.

The furnaces were extended to the basement, and the upper parts of the unit, consisting of forced and induced draft fans, projected through the original boiler room roof in the case of boiler 9. In the case of boiler 10, which is now being erected, the forced and induced draft fans are set in the space to the side of the boiler and below the original roof.

These two units occupied alternate original battery spaces within the building, thus leaving plenty of space on either side of each boiler unit. Each unit had an individual stack extending 125 ft. above basement floor.

Boiler 9 is arranged with both forced and induced draft fans installed above the boiler proper, with the natural route of the gases upward to the induced draft fan and stack and the passage downward from the forced-draft fan through the tubular air preheater to the burner.

The whole boiler is incased in sheet metal plates attached to the steel frame work supporting the boiler.

With the natural convection currents of air ascending on all sides of the boiler, and with the forced-draft fan taking its air from this elevated position, it was natural to install a large umbrella-shaped casing around the induced draft fan and stack, from the top of which all air is drawn by the forced-draft fan. This arrangement resulted in the unavoidable loss from the boiler setting being turned back to the air on its way to the air preheater.

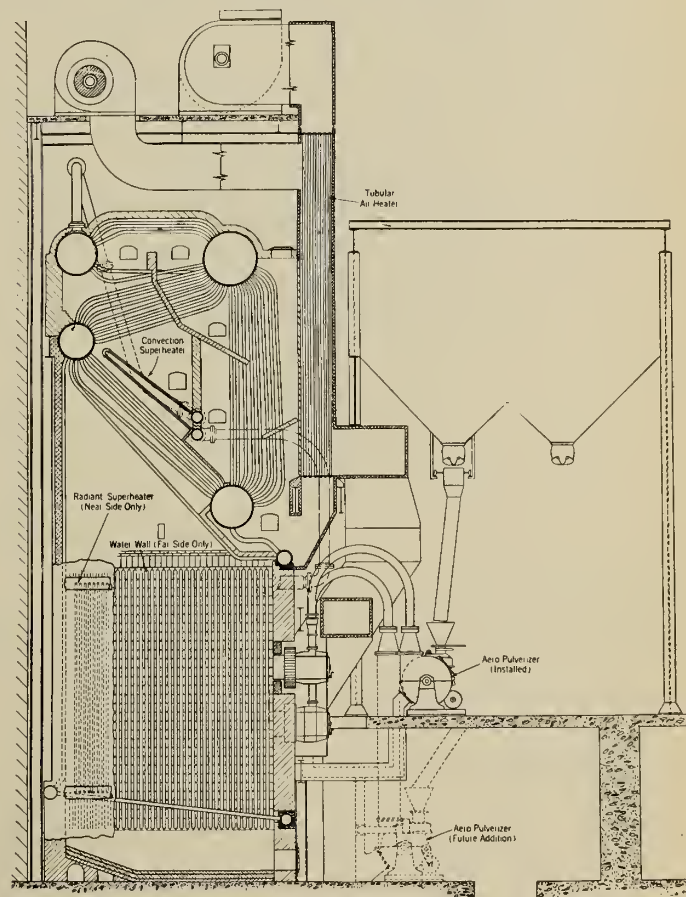


**Fig. 3—Sectional View of Boiler 9.**

In these units no gas dampers of any kind are used, the whole control of draft and air to the air preheater being effected by changes of fan speeds and by operating air foil louvres of the intervane burner.

The fans are driven by separate field supply direct current motors fed from a separately excited shunt current generator, which is part of a motor generator set. In operation, with separate field control to all three d.c. machines (two fan motors and one d.c. generator), the

## Table No. III

Coal Test of April and May 1933. — Coal Test March 1937.

Equipment—
1 Foster Wheeler steam generating unit—No. 9 boiler
2 Kidwell 4-drum boiler ..............16,500 sq. ft. heating surface.
3 Water walls tile back..............1,452 sq. ft.
4 Ash pit screen..............1,349 sq ft.
5 Total water heating surface........19,301 sq. ft.
6 Furnace volume 13,000 cu. ft. above ash pit screen

Superheater—
7 No. of extended surface one loop convection units 35 ft. long—66
8 No. of radiant units in furnace 2 in. dia. by 19 ft. long—34
9 Air heating surface 20,240 sq. ft
10 Pulverizer in service during tests—B. and W. Ball type rated per hr. 12,000 lb.

| | Particulars of Test | Original Burners | | | | | | New Type Burners | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Kind of coal | Brazeau | Michel | Corbin | McGillivray Creek | Sask. Lignite | Greenhill | Lignite and Greenhill | Hillcrest | Mohawk | Crows Nest | Greenhill |
| 12 | Date of test 1933 | April 21-22 | April 24-25 | April 26-27 | May 1-2 | May 3-4 | May 8-9 | March 8, 1937 | March 10, 1937 | March 12, 1937 | March 15, 1937 | March 17, 1937 |
| 13 | Duration of test...hr. | 24 | 24 | 24 | 24 | 24 | 24 | 12 hr. 30 min. | 16 hr. 30 min | 12 hr. 45 min. | 11 hr. 22 min. | 13 hr. 20 min. |
| | **Average Pressure, Temperature, Etc.** | | | | | | | | | | | |
| 14 | Steam pressure by gauge...lb. per sq. in. | 416.1 | 416.2 | 417.24 | 416.8 | 416.2 | 416.6 | 416.5 | 419 | 425 | 420 | 419.5 |
| 15 | Steam temperature by thermometer...deg. F. | 706 | 729 | 713 | 721.25 | 712 | 734.25 | 720 | 752 | 740 | 750 | 749 |
| 16 | Superheat in steam...deg. F. | 254 | 277 | 261 | 269 | 260 | 282 | 272 | 303 | 290 | 301 | 300 |
| 17 | Feed water temperature...deg. F. | 243.1 | 240.8 | 241 | 238.8 | 238.25 | 239.25 | 243 | 248 | 253 | 257 | 253 |
| 18 | Temperature of gases leaving boiler and entering air preheater. deg. F. | 506 | 511 | 519 | 521 | 548 | 530 | 521 | 534 | 540 | 540 | 540 |
| 19 | Temperature of gases leaving air preheater...deg. F. | 340 | 342 | 353 | 347 | 370 | 356 | 335 | 334 | 333 | 340 | 340 |
| 20 | Temperature of air entering air preheater...deg. F. | 109 | 113 | 104 | 111 | 111 | 115 | 96 | 94 | 97 | 92 | 98 |
| 21 | Temperature of air leaving air preheater...deg. F. | 366 | 367 | 380 | 373 | 397 | 380 | 358 | 352 | 346 | 354 | 355 |
| 22 | Carbon dioxide ($CO_2$)...per cent | 14.1 | 14.0 | 14.1 | 13.0 | 14.9 | 14.9 | 13.85 | 14.60 | 14.62 | 14.73 | 15.30 |
| | **Particulars of Fuel** | | | | | | | | | | | |
| 23 | Moisture...per cent | 1.80 | 2.1 | 1.55 | 2.45 | 32.4 | 2.225 | 32.95<br>1.50 | 2.25 | 2.12 | 1.75 | 1.35 |
| 24 | Ash...per cent | 14.73 | 7.176 | 16.74 | 14.47 | 7.436 | 18.00 | 9.6<br>17.0 | 18.18 | 17.78 | 7.30 | 16.82 |
| 25 | B.t.u...per cent | 12,660 | 13,788 | 12,160 | 12,788 | 7,478 | 12,500 | 7,140<br>12,500 | 12,464 | 12,250 | 14,185 | 12,698 |
| 26 | Average combustible left in ash pit refuse...per cent | 1.75 | 6.83 | 2.0 | 0.05 | 2.50 | 7.00 | | | | | |
| 27 | Average power taken to pulverize one ton of coal...kw.h. | 11.44 | 11.85 | 11.58 | 13.3 | 19.17 | 13.3 | 21.01 | 17.1 | 14.57 | 15.66 | 14.57 |
| | **Weights of Water and Coal** | | | | | | | | | | | |
| | | | | | | | | 59,020*<br>83,370† | 3,450*<br>142,910‡ | 2,475*<br>121,870§ | 50*<br>95,320‖ | |
| 28 | Total weight of coal fired...lb. | 175,080 | 171,483 | 193,590 | 181,347 | 299,228 | 171,441 | 142,390 | 146,360 | 124,345 | 95,370 | 123,730 |
| 29 | Total weight of water evaporated...lb. | 1,586,181 | 1,603,378 | 1,652,890 | 1,615,113 | 1,568,978 | 152,638 | 981,640 | 1,385,000 | 1,164,500 | 1,052,730 | 1,177,860 |
| 30 | Evaporation as fired...lb. | 9.060 | 9.350 | 8.5381 | 8.9062 | 5.243 | 8.961 | 6.894 | 9.463 | 9.365 | 11.0384 | 9.520 |
| 31 | Equivalent evaporation...lb. | 10.761 | 11.252 | 10.1945 | 10.6963 | 6.2704 | 10.82 | 8.245 | 11 450 | 11.210 | 13.235 | 11.449 |
| 32 | Factor of evaporation | 1.1877 | 1.2035 | 1.194 | 1.201 | 1.1959 | 1.2081 | 1.196 | 1.210 | 1.197 | 1.199 | 1.206 |
| 33 | Efficiency of boiler and air heater...per cent | 82.48 | 79.19 | 81.34 | 81.24 | 81.36 | 83.57 | 85.48 | 89.1 | 88.76 | 90.54 | 87.48 |

**Fineness of Pulverizing**

| | | | | | Average of five different rates of feed | Lignite and Greenhill | Hillcrest | Mohawk | Crows Nest | Greenhill |
|---|---|---|---|---|---|---|---|---|---|---|
| 34 | Brazeau at 7,900 lb per hr. | 99.6% through 40 mesh | 91.7% through 100mesh | 81.3% through200mesh | Through 40 mesh.... | 95.26% | 98.19% | 98.45% | 98.81% | 98.29% |
| 35 | Michel at 9,900 lb. per hr. | 98.3% through 40 mesh | 81.2% through100mesh | 72.1% through200mesh | Through 100 mesh.. | 81.00% | 89.36% | 89.12% | 92.91% | 90.16% |
| 36 | Corbin at 9,900 lb. per hr. | 98.7% through 40 mesh | 87.4% through100mesh | 78.4% through200mesh | Through 200 mesh.. | 70.88% | 79.41% | 78.05% | 84 21% | 80.98% |
| 37 | McGillivray at 8,400 lb. per hr. | 97.1% through 40 mesh | 80.9% through100mesh | 70.0% through200mesh | Kw.h. generated ..... | 85,350 | 126,200 | 106.300 | 96,900 | 107,900 |
| 38 | Sask. lignite at 8,350 lb. per hr. | 99.65% through 40 mesh | 92.2% through100mesh | 83.8% through200mesh | % rating turbine..... | 45.5 | 50.9 | 55.5 | 56.91 | 54.08 |
| 39 | Greenhill at 9,000 lb. per hr. | 97.7% through 40 mesh | 79.3% through100mesh | 67.7% through200mesh | FW. kw.h. lb......... | 11.501 | 10.974 | 10.954 | 10.860 | 10.916 |
| | | | | | Coal kw.h. lb....... | 1.668 | 1.159 | 1.169 | 0.984 | 1.146 |

*Greenhill. †Lignite ‡Hillcrest. §Mohawk. ‖Crows Nest.

voltage is varied on the generator for general changes in capacity required from fans, and the motor fields are changed to produce the required relative speeds for forced-draft and induced draft fans to secure the proper draft or air pressure to burners.

The general arrangement of these two units is shown on sectional views of boilers 9 and 10. (Figs. 3 and 4).

It will be seen that boiler 9 has a 13,000 cu. ft. furnace with water cooled walls on back and one side, with steam cooling in the form of superheater tubes on one side wall and with a water cooled ash pit screen in the form of 4-in. tubes on one-foot centres placed about six feet above the ash pit floor.

The burner wall is entirely of refractory material, with six 27-in. Foster Wheeler intervane burners in this wall, all supplied from three pulverizers. Each pulverizer supplies two burners, each of which may be shut off independently. Two of the pulverizers are rated at 8,000 lb. per hour each, one motor driven and the other steam turbine driven and operated at 1,200 r.p.m. The third pulverizer, rated at 12,000 lb. per hour is for base loads and is a motor driven ball mill operating at 138 r.p.m. This pulverizer supplies two main burners and also a smaller half size burner within one of the main burners which is closest to the radiant superheater at one furnace side wall.

This small burner is operated or not operated to give a measure of control of the superheat at the boiler steam outlet.

The burners as originally supplied, which were used during the 1933 coal tests, are shown in Fig. 3 in the front wall of boiler 9.

The arrangement of burners shown in Fig. 4 for boiler 10 was applied to boiler 9 in October, 1935 with a marked improvement in efficiency over the original burners used during the tests reported on in Table III, which is verified by the improved results obtained in the 1937 series of tests.

Boiler 10 has only four burners of the same size as boiler 9 burners, two of which are supplied by a ball mill driven by a 100-hp. motor.

The two remaining burners are to be supplied by one No. 4 Riley Attrita and an oil atomizer for emergency operation in case of the single pulverizer having to be suddenly taken out of service for any reason.

### Pulverized Coal Burning

Burning coal in pulverized form presents its own problems, as the pulverized coal is floated into the furnace by air. Although the coal is finely divided, the necessary scouring action of the air on the coal cannot be readily attained even by the turbulent burners which only give a difference of velocity of coal and air for a short distance from the burners. Even this turbulence, if given in a whirl, and if at excessive speed, will throw coarse particles of coal outside the flame, resulting in loss of fuel to the ash pit.

In any case the coal particles are soon surrounded by an envelope of carbon dioxide and inert gases that prevents maintenance of the first rapid phase of combustion.

This slowing up process of burning is in practice compensated for by having large furnace volume to allow of particles remaining in the heated portion of the furnace for sufficient time to allow of reasonably complete combustion.

The author's experience has been that with rates of combustion varying through a range of four to one, really fine pulverization (85 per cent through a 200-mesh screen) is necessary to prevent particles of carbon falling to the ash pit or being caught up as second pass grit.

The natural laws supporting this improved condition of burning with finely pulverized coal are well known in that the finer particles expose an increased surface for a given weight of coal particles and also a smaller weight of each particle has to be consumed in a given unit of time.

The percentage of volatile constituents of the coal has a marked influence on speed and completeness of burning, the higher percentages of volatile having the advantage, although some compensation is effected in low volatile coals when their nature or grindability allow of a product with a high percentage of extreme fines.

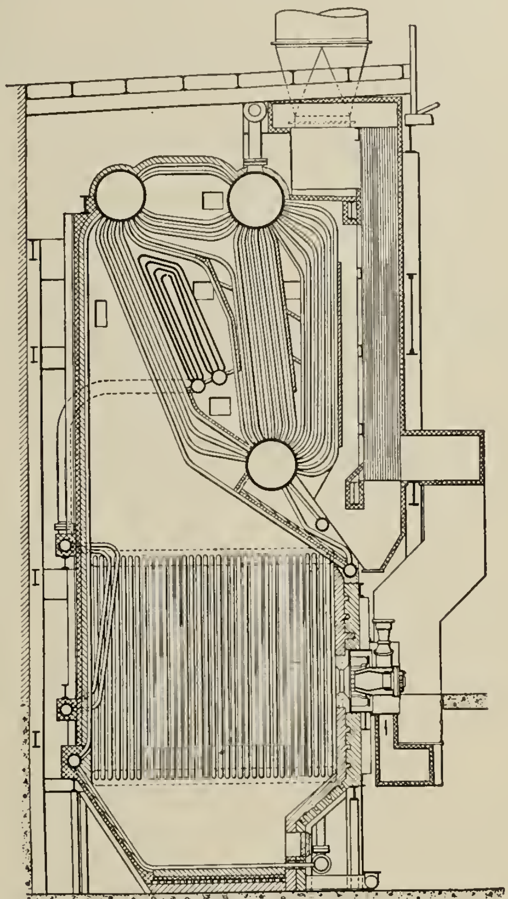

**Fig. 4—Sectional View of Boiler 10.**

### Experience with Pulverized Coal

The author's first experience with pulverized coal burning was with the low ash bituminous coals formerly burnt on stokers. In the first pulverized fuel installation, in which Riley Attritas were used without preheated air, a limited number of trials on other coals indicated that the use of low ash bituminous coals should be continued with the pulverized system burning equipment.

With the installation of boiler 9, with preheated air, it was felt that further trials should be made and during 1933 the tests, results of which are reported in first section of Table III, were completed. The latest trials have now been completed with the results shown in the second section of Table III.

After about nine years' experience with pulverized fuel burning, the outstanding conclusion is that the fuel should be ground to extreme fineness with the rather low volatile content of our western Canadian bituminous coals.

Another conclusion is, that despite almost similar analysis, the coals have widely different characteristics of 'grindability.' Even with an equipment having plenty of adjustment for carrier air to lift the pulverized coal from the pulverizer, it seems at times impossible to secure uniform fineness in some coals, because their fracture results in the formation of thin flakes that are lifted out of the pulverizer by carrier air before sufficient work has been done on them to reduce to a smaller size.

This characteristic of fuel cleavage at the final stage when reducing to fine particles will be realized when the result of the second test in the first section of Table III is noted. This coal, although of the highest B.t.u. and lowest ash content of the series of tests in April and May, 1933, gave the lowest efficiency of the series, probably due to the high percentage of combustible in the ash pit refuse and possibly a greater percentage of combustible carried through the boiler.

It was evident that the nature of the cleavage of coal in pulverizing resulted in a large percentage of flakes, indicated by the rather low power consumption per ton of coal pulverized.

On the other hand some coals will grind to fines readily, most likely by fracturing to produce particles more cubical in shape, and consequently not so readily lifted out of the pulverizer by the carrier air. These will require more work to reduce to a high percentage of fines.

An example of this condition is the Saskatchewan lignite used during the test of May 3rd and 4th, 1933, shown in the first section of Table III, in which the highest percentage of fines resulted. This lignite required over 50 per cent more power to pulverize than some of the bituminous coals, but the fact that it could be pulverized with a higher percentage of fines allowed it to be used successfully despite its high moisture content.

On this series of 1933 tests, the only bituminous coal (or rather a coal approaching a semi-anthracite) that shows such a freedom from large particles is the Brazeau coal tested on April 21st and 22nd, which is really of a friable nature and readily breaks into fines with a low power consumption per ton; this almost neutralized the disadvantage of having a volatile content of only 16 to 18 per cent. This coal is from the Edmonton field, the mine being located at Nordegg, southwest of Edmonton, Alberta.

This same condition is shown also in the results with the Fernie or Crow's Nest coal in the last test but one of the 1937 series, as shown on Table III.

From experience the author believes that with coals of similar general chemical characteristics, trials of their grindability and observation of the nature of the pulverized product, such as the amount of coarse particles carried to furnace, and the combustibles in the ash pit and second passes of boiler, a definite judgment of their relative value can be arrived at without the necessity of evaporation tests, of course after considering the B.t.u. per dollar of total cost of fuel, which must include all transportation and handling of coal, pulverizing, and removal of eash.

### Burning Lignite in Pulverized Form

*Results with Saskatchewan lignites*

The Saskatchewan lignite of 35 per cent moisture, 8 per cent ash, 7,000 B.t.u., with an ash melting point below 2,000 deg. F. has been successfully burned in the raw state with boiler 9 and the ball type pulverizer, with results as shown on Table III under date of May 3rd and 4th, 1933. The conclusion was reached that the raw state is the proper state to consider for grinding and preparing for furnace.

Many attempts had been made to reduce the amount of moisture in the lignite before shipment, as the transportation charges to Regina equal approximately five times the cost of the lignite at the mine. It was naturally assumed that if the 35 per cent moisture content could be reduced considerably, the benefit from lower freight charges would allow of the lignite competing with other coals to a greater radius from the mine district.

The first trial was to reduce moisture to approximately 25 per cent by drying at the mine, and make trial shipments and burning tests of the lignite with this reduced moisture content. Shipments of the partly dried lignite did not have a happy time, as even in the two days' journey from the point of shipment to the plant, self-ignition often occurred with dire results to the lignite and sometimes the car used for transport.

In addition to this hazard, it was found that the partly dried lignite had a toughened condition that made it resist pulverization, with the result that a given pulverizer apparently had no greater capacity in heat value of the product than could be obtained with the undried lignite.

Trials were then made to obtain partial drying at the plant by passing the raw fuel over an idle underfeed stoker with warm air fed through the tuyeres and through the fuel bed, but with no lighting of fires.

With this system of drying it was not possible to feed the heated lignite (which was reduced to mush or small size) to the pulverizer, as in the experiment the temporary course of transfer allowed the lignite to cool off. The only result of these trials was a confirmation of the opinion that a greater pulverizer capacity could not be obtained with the partly dried lignite when the processes of drying and pulverizing are not made sufficiently continuous to avoid the toughening and resistance to grinding which occurs when the lignite is allowed to cool.

Other attempts were made to have the lignite not only dried, but carbonized, with the resulting char shipped to the plant.

This condition did not bring freedom from self-ignition of the product in shipment. The attempts made to burn it in pulverized form in boilers 7 and 8 served by Riley Attritas, which furnaces had large areas of the water walls in the hot zone of furnace covered with about one inch of refractory, resulted in such a high furnace temperature being attained that the low melting-temperature ash was carried through the boiler and interdeck superheater tubes, repeating the experience with underfeed stoker conditions, and blocking the gas passages from the furnace.

Thus attempts to avoid the freight on the moisture content of the lignite were not successful and it was decided only to consider burning in the natural raw state.

Tests of preparing and burning from the raw state showed an efficiency upwards of 81 per cent, which was considered satisfactory for operation at times when load conditions did not exceed the capacity of the pulverizer to prepare the lignite.

To allow of a quick or gradual change from the bituminous coals that were required on peak load to the lignite which could only be used at times of very light load for about seven hours each day, an arrangement of divided coal pocket and separate feeder was installed with the result that a mixture of coal and lignite in any proportion could be fed to the base load pulverizer.

This arrangement worked satisfactorily with the division of the two fuels shown on a typical chart for Sunday, January 25th, 1934. (See Fig. 5).

The economical results that can be expected from burning a high moisture lignite and a low moisture bituminous in proportions to allow of furnace condition of somewhere near the optimum amount of 6 per cent water vapour for maximum speed of combustion have been verified in actual practice, in that long period tests with the mixture and similar periods of operating on straight bituminous coal show a drop in boiler efficiency of less than 0.5 per cent below that reached with bituminous coal alone.

This is best illustrated by the following table showing the result of operating with the original burners on boiler 9.

Table IV

Summary of Operating Results Comparing Mixed and Straight Bituminous Coal

| | Jan. 31st, Feb. 1st and 2nd 1934 | Feb. 5th, 6th and 7th 1934 |
|---|---|---|
| Steam pressure (gauge).......lb. per sq. in. | 412 | 409 |
| Steam temperature....deg. F. | 757.3 | 755.2 |
| Average feed temp.....deg. F. | 242.4 | 241.7 |
| Total steam flow..........lb. | 3,430,000 | 3,460,000 |
| Total pounds of coal:— | | |
| Bituminous................ | 314,270 | 384,800 |
| Lignite.................... | 119,700 | none |
| Total heat given to feed water and steam...........B.t.u. | 4,056,318,000 | 4,090,412,000 |
| Total heat in coal......B.t.u. | 4,806 014,700 | 4,829,240,000 |
| Greenhill 12,550 B.t.u. per lb. | | |
| Lignite 7,200 B.t.u. per lb. | | |
| Boiler and air heater efficiency —per cent................ | $\frac{4,056,318,000}{4,806,014,700} = 84.4$ | $\frac{4,090,412,000}{4,829,240,000} = 84.7$ |

The first test on the 1937 series shown in Table III, gives the result obtained when burning the two fuels in the same furnace, but prepared in different pulverizers and fed through separate burners.

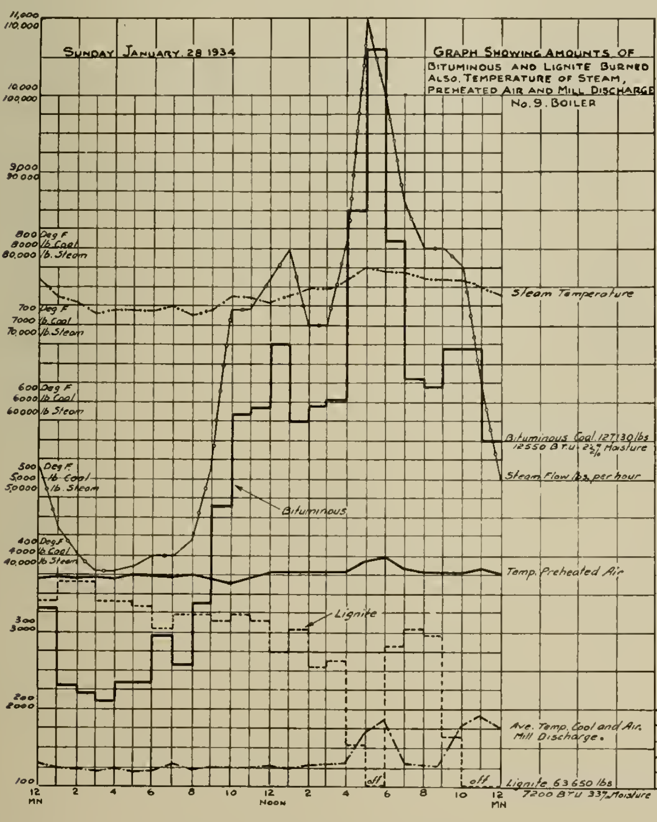


**Fig. 5—Coal Burned and Temperatures of Steam, Preheated Air and Mill Discharge on Boiler 9.**

This method of burning gives a lower efficiency than when the mixture can be made in one pulverizer and fed thoroughly mixed through the same burner.

Due to the nature of the lignite there were other conditions to be met in burning in pulverized form that only became apparent after extended experience.

In burning with preheated air in boiler 9 the intervane burner bodies are located in and supplied with secondary air from a plenum chamber with tangential louvres that have variable openings for secondary air control for operation and could be shut off completely in case the burner is out of service.

The primary or carrier air is fed with a tangential whirl close up to the refractory-formed mouth of burner in furnace wall, the whole being whirled through the opening into furnace. In practical working some very small quantities of siftings of the fine coal are not carried into the furnace, but drop to the bottom of the plenum chamber.

With bituminous coal no detrimental effect from this condition was noticed other than the necessity of cleaning out whenever access to the plenum chamber was required at period of boiler shut downs. With lignite, however, the temperature of the preheated air, together with its drying effect, was sufficient to cause self-ignition, which resulted in the slow burning of these siftings, a shower of sparks being carried through the duct which leads from the bottom of the plenum chamber to the pulverizer carrier-air fan suction.

No explosion resulted, but to avoid any possible danger, the plenum chamber bottom was made in steep hopper form with the lower parts vented to the furnace bottom with a 2-in. pipe connection, with the result that the fine siftings were carried to the furnace by the flow of forced-draft air through that pipe.

In continued burning of mixed lignite and bituminous coals in the large cooled-wall furnace at the capacity required to carry the regular load, no trouble was encountered by ash slagging on walls or being carried through the boiler to form bird-nesting, troubles sometimes encountered where high furnace temperatures must be maintained. But lignites were not fed at times when high average furnace temperatures were required, as in the regular routine the lignite feed was reduced as greater capacities were required from the boiler, and completely stopped at times of heaviest load when furnace temperatures were highest.

### *Results with Alberta lignites (Drumheller Field)*

While no extended operation of the pulverized fuel section of the plant has been undertaken with Alberta lignite, three sample cars from this field were burned in order to see if the characteristics of this lignite were suitable to burn in pulverized form and if any slagging or bird nesting in boiler tubes would result if a fair rating were attained in the furnace.

The pulverizing was done in the ball type pulverizer with the results as to grindability and capacity of pulverizer shown in Table V, which also includes supporting conditions during the burning.

It will be noted that a high percentage of the product would not pass a 40-mesh screen, which condition was reflected in the percentage of combustible in the last pass of the boiler. On the other hand, the ash pit refuse showed a small percentage of combustible, as with all lignites small particles continue combustion at low temperatures on the ash pit hearth where small leaks of air at doors, and air deliberately let in through ash pit door register, flows over the ash pit floor in a layer, absorbs radiant heat from the flame above, burns the unconsumed carbon, and thus shows low percentage of combustible when the ash pit refuse is analysed.

The later passes of boiler tubes have no such condition of large amounts of free oxygen and active radiant heat to continue the combustion process.

There was no indication of slagging of furnace or tubes in the rather short periods of burning these lignites.

### Oil Equipment

In addition to coal and lignite another form of by-product fuel is available, as with several oil refineries located in proximity to Regina, still-bottoms or bunker "C" fuel

Table V

Observation Runs on Drumheller Lignite, December 15th, 16th and 17th, 1936

Furnace volume, cu. ft., 13,000.

All walls of furnace, except burner wall, water or steam cooled and ash pit water tube screened.

Type and capacity of boiler: four drum, bent-tube, 150,000 lb. steam per hour (rated capacity) at 430-lb. pressure, 750 deg. F. final steam temperature.

Type and capacity of No. 3 pulverizer: pressure type ball mill, 6 tons per hour on coal having grindability factor of 82 per cent.

| | Car No. 345271 | Car No. 345061 | Car No. 343337 |
|---|---|---|---|
| Shipping point of lignite | East Coulee | Rosedale | Kneehill |
| Start lignite feed to pulverizer | 9.00 a.m. | 9.00 a.m. | 9.00 a.m. |
| Finish lignite feed to pulverizer | 9.25 p.m. | 11.02 p.m. | 9.10 p.m. |
| Total tons of lignite | 46.7 | 52.07 | 45.85 |
| Tons of lignite per hour | 3.73 | 3.72 | 3.77 |
| Total kw.h. to pulverizer | 846.0 | 978.0 | 835.2 |
| Kw.h. per ton (pulv.) | 18.11 | 18.78 | 18.21 |
| Average amperes pulverizer motor at 440 volts | 97.5 | 98.5 | 99.0 |
| Pounds of lignite burned | 95,240 | 104,140 | 91,700 |
| Pounds of oil required in addition to lignite to meet steam demand on boiler | 46,420 | 49,460 | 46,300 |
| Total pounds of steam generated | 1,310,000 | 1,390,000 | 1,222,000 |
| Average steam pressure (gauge) lb. per sq. in. | 420 | 416 | 420 |
| Average steam temperature deg. F. | 743.5 | 756.0 | 749.1 |
| Average feed water temp. deg. F. | 267.0 | 264.0 | 265.0 |
| Average temp. air to pulverizer and secondary air deg. F. | 365 | 360 | 367.5 |
| Average temp. air and lignite from pulverizer deg. F. | 136.6 | 136.4 | 133.5 |
| Average temp. gas to preheater deg. F. | 534 | 560 | 565 |
| Average temp. gas to stack deg. F. | 365.0 | 345.0 | 353.0 |
| Average $CO_2$ in flue gases with mixture of fuels per cent | 14.11 | 13.98 | 13.92 |
| Product fineness, | | | |
| through 40 mesh per cent | 95.05 | 98.4 | 95.5 |
| through 100 mesh per cent | 70.65 | 84.4 | 65.25 |
| through 200 mesh per cent | 56.65 | 68.15 | 44.05 |
| Analysis: lignite— | | | |
| moisture per cent | 18.2 | 17.0 | 17.6 |
| ash per cent | 10.90 | 13.01 | 12.36 |
| B.t.u. per lb. | 9160 | 8880 | 8900 |
| Combustible in fly ash (last pass) per cent | — | 8.0 | — |
| Combustible in ash (ash pit) per cent | — | 0.25 | — |

oil can be obtained in considerable quantities at a price to compete with the by-product coal fuels.

In order to provide for the use of this oil fuel as found desirable, the necessary tanks, heaters and other essentials are installed and oil burners or atomizers are fitted to all boilers with furnaces for pulverized fuel operation.

The burner equipment in boilers 9 and 10 consists of four burners in each furnace, namely two Peabody wide range burners with a capacity of 250 Imp. gall. per hour each and two non-variable Monarch atomizer tips with a capacity of 150 gall. per hour each.

These oil atomizers are fitted within the coal burners and the same secondary air and control serves for both oil and coal.

The furnace being 18 ft. deep from burner wall, excellent burning conditions with oil prevail and it is possible to burn oil and coal in the same burner simultaneously; it is more usual to operate with some coal burners and oil burners in the same furnace.

In regular practice changes are made from coal to oil or reverse in about one minute.

The supply of oil is not sufficient for continuous complete plant operation.

### Condition of Progress

As first stated Regina is situated far from any available water power and has, therefore, developed a steam plant to meet its power requirements. The results are best shown on the 1937 coal tests, which do not cover a full twenty-four hour period of plant operation, but do represent in the statement of boiler efficiency and coal per kilowatt hour the results obtainable with the average loading on boiler and turbine shown.

The steam turbine in regular service during the 1937 tests was designed for 360 lb. gauge pressure and 725 deg. F. temperature and an absolute back pressure of one inch mercury, but during these tests the vacuum maintained was less than 0.6 in. back pressure.

The by-product fuels are available at such a price, including all costs of transportation, handling, pulverizing and removal of ash, that 5,000,000 B.t.u. can be fed to the furnace for $1 cost.

The plant now in use cost less than $90 per kw. of modern equipment installed.

# British Columbia Coals in Metallurgy

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

**SUMMARY.—After discussing briefly the objectives desired in metallurgical furnaces of various kinds, the paper deals with powdered coal burners, particularly those for small furnaces (down to one ton per day). Notes are also given on storage, drying and pulverizing equipment for bituminous and lignitic coals.**

A search of the literature on the utilization of coal reveals a wealth of information on almost every phase of the subject with one exception. This exception lies in the part played by coal in metallurgy. Some aspects of this application in connection with British Columbia coals will be submitted in this paper.

### Coal Fields in B.C.

The coal fields are liberally distributed in this province. There are three principal producing areas so located as to supply the consuming centres with the minimum freight haul. The Vancouver Island district, oldest and largest producing field in the province, is located on the east coast on tide-water in close proximity to the larger centres of population on the island and mainland. The interior of B.C. has several sources of supply; in the south, Merritt and Coalmont, with Princeton and Tulameen. The Crow's Nest Pass district on the eastern boundary of the province is close to the industrial centre of Trail. In the north there are known coal fields which have not been developed to any extent as yet, but which are available if the need arises.

The coal produced from these districts has been estimated for 1936 as follows*:—

| | |
|---|---|
| Vancouver Island | 712,913 tons (2,240 lb.) |
| Crow's Nest Pass | 459,073 tons (2,240 lb.) |
| Nicola-Princeton | 158,365 tons (2,240 lb.) |
| Northern | 5,559 tons (2,240 lb.) |

In character the coal produced in B.C. ranges from low-volatile high-rank bituminous to high-volatile sub-bituminous and lignitic. Some anthracite has been found on the Queen Charlotte Islands and in the northern part of the province, but these districts supply only the local needs and are largely undeveloped. Much of the coal found in B.C. is suitable for the manufacture of coke, the beehive ovens in the Crow's Nest Pass area having long supplied the requirements of the metallurgical industry in the Boundary District. These coals are all low in sulphur content, rarely showing more than 1 per cent.

Cleaning plants have been installed by several of the larger producers and low ash coal is available.

Some years ago twelve representative coals were sent to Ottawa at the instigation of the British Columbia government. These were tested as pulverized fuel under a boiler in the Fuel Research Laboratories, and the data gathered were fully set out in a paper by E. S. Malloch.† Ash in the test coals ranged from 7.7 per cent in a Crow's Nest coal to 17.2 per cent in an Island coal. Moisture varied from 1.7 per cent in a Crow's Nest coal to 22.9 per cent in an interior coal. Thermal value was lowest in the high moisture coal at 8,110 B.t.u. and highest in a Crow's Nest coal at 13,950 B.t.u. Evaporation varied from 5.34 to 8.54 lb. of water per lb. of fuel fired. Ash fusion temperature varied from 2,032 deg. F. to over 2,700 deg. F.

*Figures furnished by B.C. Dept. of Mines.

†Mines Branch, Dept. of Mines, Ottawa, Memo. Series No. 56, 1932.

### Selection of Coal

Every fuel problem has its own variables and factors which can be determined and which should be developed before any binding decision regarding the type of fuel to be used is reached. If coal is selected as the most economical and most suitable fuel for a particular purpose adequate consideration should be given to the type of coal which will best satisfy the specific requirements. It is highly unsatisfactory to judge the merits of a coal on its proximate analysis or thermal value alone because there are other properties which may have a greater bearing on the success or failure of the fuel. For instance, if the coal is to be pulverized the grindability is an important factor. If it is to be burned on a chain grate or travelling stoker it is essential to know the coking properties. Another point which might easily assume a vital magnitude is ash fusion or softening temperature.

Coals which are satisfactory when used on one type of equipment are not necessarily so on other equipment of similar although slightly different type. There is also a best technique for burning each coal and this technique will vary with the duty and type of equipment used. Available equipment, available fuel and required duty should all receive careful consideration. The variation of several factors which may be of very minor individual importance may, when developed collectively, exert a profound influence on the fuel problem.

The preparation of the coal, the design of plant and its operation are not static and it would be impossible to compile a code or set of rules which would be flexible enough to cover all the factors involved in the selection of coals. The burning characteristics of a coal are frequently altered by sizing and cleaning. It is not uncommon for the ash-softening temperature to be changed in this way to such an extent that the lower ash cleaned coal is unsatisfactory for use under the same conditions in which the high ash uncleaned coal was eminently suitable. An examination of the ash analysis might explain this phenomenon.

Once the coal from any particular source has been selected and found to be satisfactory in use, the proximate analysis can usually be relied on for checking purposes.

In actual practice there is only one way to discover the most suitable among a number of similar coals for any specific purpose and that method is the time-tested one of trial and error.

### Metallurgical Coal Problems

From a fuel standpoint metallurgical furnaces are usually operated with two objectives in view: first, a certain optimum temperature is required; and second, a certain furnace atmosphere is desired. The first objective is not necessarily the development of the highest possible temperature, although this may be required in certain instances. In the non-ferrous industry the volatilization of metal is an important consideration and it is desirable on this account to maintain the lowest temperature which is compatible with the operation being carried out in the furnace. The second consideration, the furnace atmosphere has an important bearing on the type of reaction going on in the furnace. The atmosphere desired may be reducing, oxidizing or neutral and its character may be altered from time to time to suit the condition of the furnace charge.

If pulverized coal is used these two primary objectives are relatively easy of attainment, but several other factors complicate the situation. It may be essential to keep the charge as free as possible of coal ash, either because ash is objectionable in the charge or on account of the ash being refractory. In either case the remedy is obvious. But it may be necessary to use the same coal on a number of furnaces, each of which is doing a different job. Under these conditions the problem becomes rather complicated and the best compromise may not be entirely satisfactory.

A specific instance may be indicative of the way a problem may be attacked. Some years ago a relatively short reverberatory furnace was built to smelt wet copper concentrates using pulverized coal as the fuel. A great deal of trouble was almost immediately experienced when the coal ash melted and slagged the flues. A search revealed an available coal having a high melting point ash and the difficulty was alleviated somewhat by this expedient. Unfortunately this new coal was of high-rank bituminous type and it was difficult to secure complete combustion in the furnace, so that hot flues persisted. (It should be pointed out at this time that local knowledge of the principles of powdered coal combustion was in the course of development.) Further testing evolved a turbulent burner which so improved combustion that the flues ran cool and no further slag troubles were encountered with any kind of coal.

It is unusual to specify colour in coal ash, although this may be important. One furnace in the Trail smelter is producing a leaded zinc oxide which may be used as a pigment, in fact it is so used for locally made paints. Pulverized coal is burned in this furnace and the colour of the coal ash shows up very prominently in the oxide. A considerable search was carried on before a neutral coloured ash was discovered.

When absolutely no coal ash is allowable in furnace gases or charge, the operator must turn to the use of coal or coke on grates, unless oil, gas or electric heating are economic alternatives. In this case ash content and fusion temperature and coking characteristics require the usual consideration.

### Powdered Coal Burners

A great deal of excellent work has been done on the development of powdered coal burners for steam raising where fuel consumption exceeds 50 or 100 tons a day. But progress in the design of a burner for the consumption of a ton or so of coal a day has been slow. One reason for this has undoubtedly been that unit mills were usually installed on jobs of this small size. In an industrial plant there may easily be fifteen or more individual coal burning units and the bin and feeder system with central crushing plant has certain advantages which make its use attractive. In this case every effort should be made to find and use the type of burner which is best suited to the characteristics of the available coals.

When the use of powdered coal first became general at the Trail smelter, the most economical coal was a low-volatile high-ash slack from the Crow's Nest Pass district. It was difficult to initiate combustion and still more difficult to burn in small quantities. In the course of an extended investigation a suitable burner was developed, the basic design of which has not been altered. (Figs. 1 and 2.)

This burner was the answer to a demand for a high combustion rate in a very small furnace which required quite high temperatures for successful operation. The furnace was smelting copper dross from the lead drossing plant, with the object of making a matte which was low in lead and high in copper. It had been found that higher furnace temperatures were conducive to the production of this higher grade matte and this inducement initiated the development work. It turned out that the furnace capacity was greatly increased in addition to making a better product.

Adjustments are provided which allow alteration of the flame characteristics to suit local conditions. The size sketched is burning 7 tons a day of coal on which the ash is 19 per cent with 21 per cent volatile in a very small melting furnace. A similar burner, of smaller size of course, is burning one ton of the same coal in another furnace. One advantage of this burner is that no hot spot or ignition chamber is required to promote combustion. With proper adjustment a stable flame can be made to break within 6 inches of the burner tip.

In burning a coal of this nature the importance of fine grinding must be stressed. Experience shows that 80 per cent through a 200 mesh screen is the minimum requirement for the grade of coal mentioned and that this fineness may vary inversely as the volatile matter content. High ash coals are not necessarily hard to pulverize but high volatile coals are usually so.

In adapting this burner, which was designed for use with 60-80 lb. primary and 40 oz. secondary air, to different conditions where these particular air supplies are not available, it should not be necessary to alter the basic design. A slight alteration in the angle and number of secondary air vanes will compensate for lower air pressure. It is particularly desirable, however, to retain the high pressure primary air supply. Consumption on a single unit is only 30 c.f.m. for a 50-ft. straight run. Another

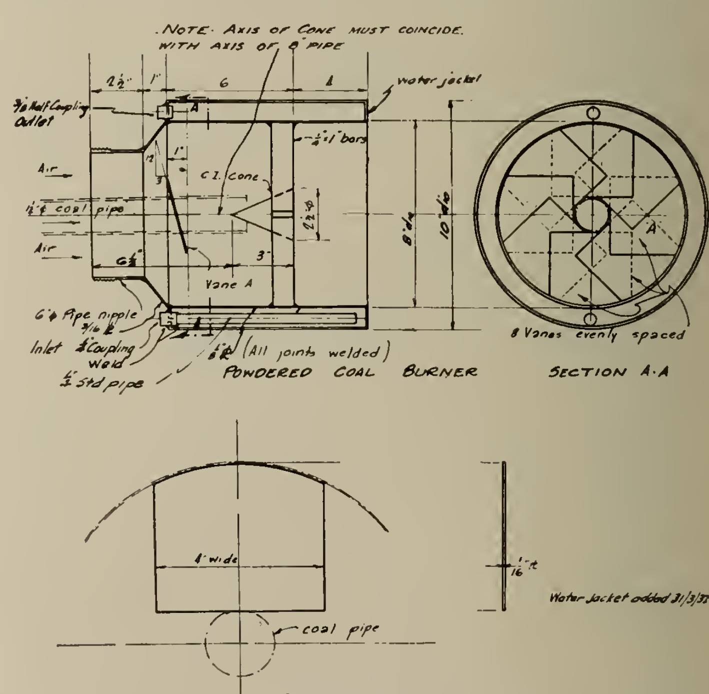


**Fig. 1—Detail of Powdered Coal Burner.**

advantage of using high pressure primary air on small furnaces is that the coal delivery line may be made of quite small and easily handled pipe. Ordinary black iron pipe is found to have a surprisingly long life on these installations.

It used to be customary to think of pulverized coal furnaces as being excessively large to burn a certain tonnage of coal. The author believes in making the radiant heat in a powdered coal flame do as much useful work as possible.

A powdered coal installation was arranged to fire a pair of 8 ft. by 60 ft. single shell rotary dryers and the fire box was made quite large. The job was reasonably successful but had a major disadvantage in the cost of fire box maintenance. One obvious way out of this difficulty was to reduce the amount of brickwork exposed to the flame but it was only possible to accomplish this and still secure good ignition by installing an adaptation of the turbulent burner shown in the sketch. The secondary air supply in this case was at 4 oz. pressure. These dryers now burn about 8 tons of coal per twenty-four hours with an ignition chamber of 48 cu. ft. and secure a heat efficiency of some 45 per cent. The material being dried varies in consistency from a thick mud to chunks of clay and the flame persists for a considerable distance into the dryer. The same type of installation is used for firing two double drum coal dryers.

Another type of burner which has enjoyed some success at this plant is similar in design to that developed by the Fuel Research Board and described as the "Z" burner in the 1933 report. The simplicity of this burner makes its use attractive in certain applications. It has been used for firing lead kettles at a feeding rate of 1 ton per day where a "lazy" flame is desirable in order to avoid local overheating of the kettle where the combustion volume is restricted. In another furnace, where a long luminous flame is desired for the drying and melting of slimes, it has obvious advantages.

The largest individual powdered coal consumer at the Trail plant is the slag fuming furnace. The application is unusual in that the coal is injected into a bath of liquid slag through tuyeres located some two feet below the surface of the bath. The operation has as its object the release of zinc from the slag and its recovery as zinc oxide. Furnace gases pass through a waste heat boiler and the oxide is eventually collected in a baghouse.

### Powdered Coal Plant

In a bin and feeder system the design of a preparation plant requires careful consideration. The types of coal likely to be used must be borne in mind. In general the plant will consist of receiving bins, coal dryers and pulverizing mills with a distributing system supplying the furnace bins. If the coal has much inherent moisture and is lignitic in character, the dryer and mill installation will be large in comparison with that required for a bituminous coal. It will not be good practice to operate the coal dryer at much over 200 deg. F. with lignite coal, since it has an unfortunate tendency to spontaneous ignition after the inherent moisture has been removed. This further reduces dryer capacity.

In handling high-ash low-volatile coals, which are difficult to ignite, the operator may easily acquire a certain carelessness about respecting the ordinary precautions which should be observed with any coal. A test shipment of high volatile coal was received at this plant about a year ago and the whole operating procedure had to be changed in order to operate safely. Dryer temperatures required very close control to avoid fires and still get capacity. Bin fires in the dried coal and powdered coal, while not frequent, were a constant source of concern. Experience at this time showed the truth of the ancient maxim that the only safe coal plant is a clean one.

Storage for dried coal should be small, particularly if lignite is being prepared. Once the coal is dried it should be kept moving until it is burned in the furnace.

At one time it was necessary to use up a supply of coke breeze by mixing it with the feed to the coal pulverizing plant. Although up to 20 per cent of the pulverized fuel was coke, the only particular difficulty that developed was

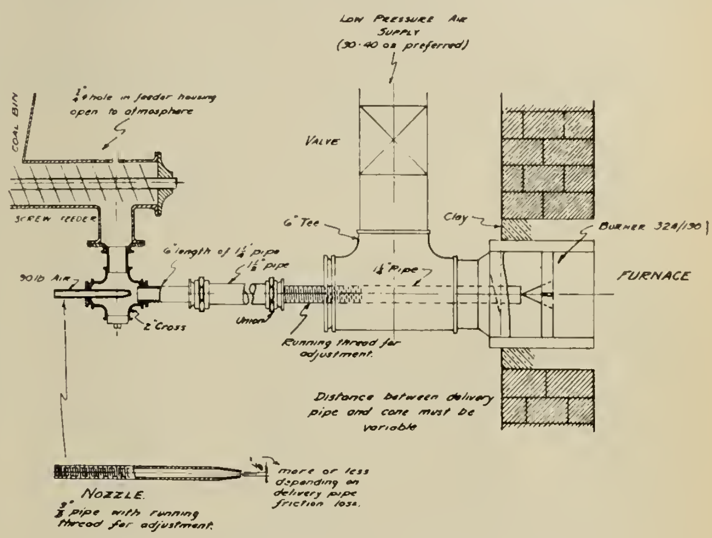


**Fig. 2—Arrangement of Powdered Coal Burner.**

in the crushing operation. The coke tended to hang back and load up the mill while the coal went through. This particular breeze contained 23 per cent ash.

Pulverizing mills are of various types, most of which have been developed to the point where maintenance is very low. Slow speed mills usually require more power than high speed mills for the same capacity.

The air pressure system of coal distribution has the advantage of being comparatively foolproof, since there are no moving parts to require adjustment. All that is necessary is a pipe line and pressure tank.

The furnace bins are usually vented through bags at the top and have some type of coal feeder mounted on the bottom. For the consumption of small tonnages of coal, the design of the feeder becomes important. Screw feeders have several disadvantages with one saving grace, simplicity. There is a field here for the development of a non-flooding feeder that will deliver a small quantity of coal to the burner at a constant rate.

The use of pulverized coal for heating has distinct advantages over the use of coal in any other form in a great many fields, both in large and small scale operations. It is flexible, efficient and can be made foolproof. It is one easy way of getting the greatest thermal value out of the fuel dollar.

# THE ENGINEERING JOURNAL

THE JOURNAL OF
THE ENGINEERING INSTITUTE OF CANADA

"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."



VOLUME XX JULY, 1937 No. 7

## The Utilization of Canadian Coals

The ten papers on Canadian coals published in this issue of The Journal treat of a number of live problems which arise in the study of this important division of the fuel resources of the Dominion. They really form a symposium on the subject, and naturally fall into groups corresponding roughly with the widely separated eastern and western areas in which nature has placed our coal deposits.

Three of them deal with coal classification and investigation, and more particularly with recent advances in this difficult field. The article by the Director of the Division of Fuels of the Dominion Department of Mines is itself a mine of ably selected information; Mr. Haanel's data are well supplemented by those of Dr. Sexton from Nova Scotia and by Mr. Stansfield's as regards Alberta coals. From the particulars given it will be evident that the public money devoted to these inquiries has been judiciously spent, both by the Dominion and the Provincial Governments concerned.

The technique of coal utilization is discussed by five authors. Conditions in many parts of Canada are such that if we are to avoid resorting to imported fuel, whether for power generation or for domestic heating, low rank coals, or a higher rank coal possibly having some difficult moisture, ash or sulphur characteristics, must be used in many places. Actual experiences in New Brunswick, Saskatchewan and Alberta (in power generation practice), and in British Columbia (in metallurgical work) are recounted by the men who have themselves been responsible for many of the successful results they report, and for the means adopted to overcome operating difficulties. Their methods of burning certain coals in pulverized form and with mechanical stokers are of considerable interest.

There are other papers of somewhat different scope. As the demand for coke for domestic purposes in Canada grew—particularly in Ontario where the competition from American anthracite was severe—the Dominion Government endeavoured to encourage the use of Canadian coals in the manufacture of by-product coke. Requirements could not be met by coke produced by the metallurgical companies, who needed practically all they could make. This led to the establishment of coke-producing companies, who succeeded in meeting the competition of imported European coke. Mr. Munroe describes the vicissitudes of their enterprise, and incidentally throws an interesting light upon the local and international factors which affect an industry of this kind.

Mr. Sutherland's story of the Saskatchewan lignite industry shows how the utilization of an abundant and easily mined natural resource may prove to be dependent on labour conditions, legislative enactments, the scale on which individual enterprises are operated, and on the transportation facilities available.

The importance to Canadian industry, and to the country at large, of the proper utilization of our coal resources is self-evident. The papers here presented bring up to date the creditable record of coal investigations in Canada, explain some of the difficulties and successes experienced in coal-burning practice, and show the decisive effect which economic conditions may exert in certain phases of the Canadian fuel industry.

## Institute Problems Considered at Recent Meetings of Council

Members will be interested to learn of the action taken by the Council, following the announcement of the result of the ballot on the amendments to by-laws, which was reported at the Council meeting of April 30th, 1937. At this meeting the Council's attention was drawn to the proposals for local co-operation which had been put forward, more particularly in Nova Scotia and Manitoba, in 1934 and 1935, and had necessarily remained in abeyance pending the result of the work of the Committee on Consolidation. As already noted in the Journal, arrangements were at once made for visits by members of Council to Winnipeg, and to Saint John and Halifax, by President Desbarats and Mr. J. L. Busfield respectively, and reports of these visits were presented at the Council meeting of May 28th, 1937.

In these reports the Council was informed that the local schemes were still under consideration. The proposals differ somewhat in the two localities, but in general involve a common executive committee and secretary, and the encouragement of local engineers to belong to both the Association and The Institute, an arrangement being also proposed for the local collection of a single fee. In Nova Scotia the scheme under discussion is one of amalgamation rather than co-operation and is being further considered there by a committee of seven members, two representing the Association, two the Halifax Branch of The Institute, one the Cape Breton Branch, and two appointed by the Council of The Institute. Professor H. W. McKiel and Mr. C. A. Fowler are acting in the latter capacity.

At this meeting of the Council Mr. R. A. Spencer reported on conditions in Saskatchewan, where a plan for local consolidation is also being studied. He then stated that there was a feeling that the Council of The Institute in the past few years had done very little to further the professional interests of members. Mr. Spencer was asked to indicate some definite lines of action by the Council which would meet the views he had expressed, and after considerable discussion the President suggested that all these matters should be referred to a small committee which would report thereon at the Plenary Meeting of Council to be held on June 14th. Upon this committee he named Messrs. F. S. B. Heward, J. L. Busfield and R. A. Spencer.

At the Plenary Meeting of Council this committee reported accordingly, suggesting a comprehensive scheme involving the establishment of the following committees:

(1) A main 'Committee on Professional Interests' (of three members) which will co-ordinate the activities of provincial sub-committees of which one should be formed in each province. This Committee on Professional Interests is also to act in all negotiations with the Provincial Associations of Professional Engineers. In addition to carrying out discussions with the several Professional Associations as regards co-operation with The Institute, these sub-committees will deal with the following other questions of interest to our members: (*a*) Salaries and Remuneration; (*b*) Professional Practice; (*c*) Junior Engineers, and (*d*) Public Education, the latter term involving action to acquaint the general public with notable achievements in engineering and the advantages of employing qualified engineers to deal with industrial and civic problems of an engineering nature, and also to promote local publicity in the various centres.

(2) It was further recommended that a 'special committee of a temporary nature' be set up to investigate and report upon the management and membership of The Institute. This committee would examine and report on such questions as possible improvement of the organization of the Council and in the conduct of Institute affairs; the standards of admission and of fees; the suitability of the present classes of membership to existing conditions; the desirability of setting up Provincial Divisions, etc.

(3) It was further recommended that there should be a 'Special Committee on Closer Relations with Other Engineering Organizations,' with a view of leading to closer relations with other engineering organizations operating in Canada, this committee to have sub-committees in provinces where such engineering organizations are active.

(4) Finally, with regard to the question of closer working arrangements with the Provincial Associations, it was recommended that the Council adopt the following resolution as a statement of its policy, this resolution to be communicated to each of the eight Provincial Professional Associations:

> "Whereas, the closest possible co-operation with Provincial Professional Associations is desirable,
>
> Now therefore, to permit of said closer relationships the Council of The Institute is prepared to negotiate agreements with the Provincial Professional Associations along the following lines:
>
> (*a*) Provision for such mutual recognition of each other's membership as may be found possible.
> (*b*) Provision for joint collection of fees where desirable.
> (*c*) Provision for reduction of fees of members belonging to both organizations.
> (*d*) Provision for liaison between the respective Councils.
> (*e*) Provision for joint operations."

All the above suggestions were adopted by the Plenary Meeting of Council, and the following committees were appointed accordingly:

(1) *Main 'Committee on Professional Interests'*

This committee also to act in any negotiations with the Professional Associations.

F. A. Gaby, *Chairman*
F. Newell
O. O. Lefebvre

*Chairmen of Provincial Sub-Committees of C.P.I.*

P. H. Buchan, British Columbia
R. M. Dingwall, Alberta
R. A. Spencer, Saskatchewan
T. C. Main, Manitoba
J. A. Vance, Ontario
J. A. McCrory, Quebec
E. J. Owens, New Brunswick
H. S. Johnston, Nova Scotia

These councillors to form their own sub-committees.

(2) *Committee on Membership and Management of The Institute*

| | |
|---|---|
| Dr. L. F. Goodwin, *Chairman* | A. J. Taunton |
| E. A. Wheatley | Brian R. Perry |
| P. M. Sauder | V. C. Blackett |
| D. A. R. McCannel | R. R. Murray |

(3) *Special Committee on Closer Relations with other Engineering Organizations*

The Institute's existing 'Committee on Relations with National Societies' (under the chairmanship of Mr. John Murphy) was appointed a Special Committee to investigate and report on the feasibility of closer co-operation with other engineering organizations. Its membership is:

| | |
|---|---|
| John Murphy, *Chairman* | A. B. Crealock |
| R. W. Angus | J. M. R. Fairbairn |
| A. B. Cooper | H. J. Roast |

Sub-committees in each province to be appointed by the above committee.

The present situation as regards The Institute's relations with the Provincial Professional Associations is, therefore, that all the Associations will receive the resolution referred to above, and in each province a local sub-committee will report to the Committee on Professional Interests the nature and results of their negotiations with the local Professional Associations.

During the discussions it was made clear that the establishment of this Committee and its sub-committees will in no way affect the discussions now being carried on by the local committee in Nova Scotia on which Messrs. McKiel and Fowler are serving. It was also agreed that none of the recommendations or agreements of these committees should become effective unless endorsed by a Plenary Meeting of Council or a majority on a letter ballot of the whole Council.

In addition it will be noted that Mr. Spencer's suggestions have led The Institute Council to appoint committees dealing with four separate groups of subjects:

(1) Means of furthering the professional interests of members.
(2) Membership and management of The Institute.
(3) Relations with other engineering societies operating in Canada.
(4) Relations with the Provincial Associations of Professional Engineers.

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## Past-Presidents' Prize 1937-1938

The subject prescribed by Council for this competition for the prize year July 1st, 1937 to June 30th, 1938, is **"Stream Control in Relation to Droughts and Floods."**

The rules governing the award of the prize are as follows:

The prize shall consist of a cash donation of the amount of one hundred dollars, or the winner may select books or instruments of not more than that value when suitably bound and printed, or engraved as the case may be.

The prize shall be awarded for the best contribution submitted to the Council of The Institute by a member of The Institute of any grade on a subject to be selected and announced by Council at the beginning of the prize year, which shall be July 1st to June thirtieth.

The papers entered for the competition shall be judged by a committee of five, to be called the Past-Presidents' Prize Committee, which shall be appointed by the Council as soon after the Annual Meeting of The Institute as practicable. Members and Honorary Members only shall be eligible to act on this Committee.

It shall be within the discretion of the Committee to refuse an award if they consider no paper of sufficient merit.

All papers eligible for the competition must be the bona fide work of the contributors and must not have been made public before submission to The Institute.

All papers to be entered for the competition must be received **not later than June 30th, 1938,** by the General Secretary of The Institute, either direct from the author or through a local Branch.


**SEMICENTENNIAL BANQUET—THE ENGINEERING INSTITUTE OF CANADA**

**Head Table Guests:**—*Left to right at top of table:* Brigadier-General C. H. Mitchell, C.B., C.M.G., C.E., D.Eng., Dean of the Faculty of Applied Science and Engineering, University of Toronto, Past-President of The Engineering Institute, Toastmaster; Sir Alexander Gibb, G.B.E., C.B., F.R.S., Hon.M.E.I.C., President of the Institution of Civil Engineers, representing the Institution of Civil Engineers and the Newcomen Society (England); The Right Hon. Lord Tweedsmuir, P.C., G.C.M.G., C.H., Governor-General of Canada, Guest of honour and principal speaker; G. J. Desbarats, C.M.G., Hon.M.E.I.C., President of The Engineering Institute of Canada; Edward P. Lupfer, vice-president of the American Society of Civil Engineers, representing the American Society of Civil Engineers; Dr. A. Surveyer, Past-President of The Engineering Institute of Canada; E. A. Cleveland, LL.D., immediate Past-President of The Engineering Institute of Canada. *Left to right around the circle:* A. M. McCutcheon, President of the American Institute of Electrical Engineers, representing the American Institute of Electrical Engineers; C. E. Davies, M.E., M.E.I.C., Secretary of the American Society of Mechanical Engineers; Brigadier-General Magnus Mowat, C.B.E., T.D., F.R.S.E. A.K.C., Secretary of the Institution of Mechanical Engineers, London; H. H. Vaughan, Past-President of The Engineering Institute of Canada; Canon H. J. Cody, President, University of Toronto; G. H. Duggan, D.Sc., LL.D., Hon.M.E.I.C., Past-President of The Engineering Institute of Canada; Dr. W. H. Brittain, Acting Principal of McGill University; A. R. Decary, D.A.Sc., Past-President of The Engineering Institute of Canada, and President of the Corporation of Professional Engineers of the Province of Quebec; J. C. Irwin, President American Railway Engineering Association; A. Frigon, D.Sc., M.E.I.C., Past-President, The Engineering Institute of Canada, representing the Ecole Polytechnique, Montreal, and the Société Française des Electriciens; W. T. B. McCormack, representing the Institution of Engineers, Australia; Major Geo. A. Walkem, Past-President The Engineering Institute of Canada; Johnstone Wright, Vice-President, Institution of Electrical Engineers, representing the Institution of Electrical Engineers; Julian C. Smith, Past-President, The Engineering Institute of Canada; F. N. Jean Gindorff, representing the Newcomen Society (United States); The Hon. C. D. Howe, Hon.M.E.I.C., Minister of Transport, Ottawa; H. E. Wimperis, President, Royal Aeronautical Society.

# The Celebrations of the Semicentennial of The Institute

The ceremonies which have just taken place in Montreal and Ottawa to commemorate the completion of fifty years of The Institute's activities will long be remembered. They were attended by members from all over the Dominion and by a host of distinguished guests from all parts of the English speaking world, while His Excellency the Governor-General honoured The Institute by his presence and his address to the members and ladies at the banquet. At the technical sessions more than twenty important papers were presented on subjects of marked interest and variety. The many official delegates brought greetings from nearly fifty sister institutions, universities and professional associations, many of them in the form of illuminated addresses.

The organization and arrangements were in the hands of a Semicentennial Committee of Montreal and Ottawa members under the chairmanship of J. L. Busfield, M.E.I.C. The Committee's activity and efficiency may be judged by the fact that, almost without exception, the various events commenced exactly at the times specified in the programme, and all were carried out with smoothness and despatch.

Several hundred delegates had registered by the time the first session opened in the Rose Room of the Windsor Hotel on the morning of June 15th, and their first act, on the call of the President, was to stand in silence for a minute as a tribute to the memory of Harrison P. Eddy, of Boston, Mass., an eminent American engineer who had come to participate in the jubilee proceedings and to receive an honorary membership in The Institute. Mr. Eddy had died early that morning in his hotel room. In announcing the sad event, the President expressed the profound regret of all present and tendered their sincerest sympathy to Mrs. Eddy and the members of the family.

The official visitors, headed by Sir Alexander Gibb, President of the Institution of Civil Engineers, James H. Herron, President of the American Society of Mechanical Engineers, H. E. Wimperis, President of the Royal Aeronautical Society and Director of Research at the Air Ministry, and Brigadier-General Magnus Mowat, representing the Institution of Mechanical Engineers, were then introduced to the meeting by F. S. B. Heward, chairman of the Reception Committee, who gave a brief outline of their careers and the organizations they represented. An interesting presentation was that by Charles Penrose, a vice-president of the Newcomen Society in the United States, who presented a letter from Sir Herbert Marler, Canadian Minister to the United States, conveying his congratulations to The Institute on its half century of existence.

On the completion of this ceremonial Past-President H. H. Vaughan officiated in announcing the award of Honorary Membership in The Institute to the following eight distinguished engineers:

R. W. Angus, Toronto, Ont.
George H. Duggan, Montreal, Que.
Harrison P. Eddy, Boston, Mass.
Sir Alexander Gibb, London, England
The Hon. C. D. Howe, Ottawa, Ont.
S. J. Hungerford, Montreal, Que.
Jacques Rabut, Paris, France
The Hon. Grote Stirling, Kelowna, B.C.

Of these, Past-President Duggan, Sir Alexander Gibb, the Hon. C. D. Howe, and Mr. Hungerford were present to receive their diplomas, which were handed to them by Mr. Vaughan with a few words of welcome in each case.

Past-President George A. Walkem took charge of the presentation of The Institute prizes and medals, which was the next item on the programme. The awards included that of the Sir John Kennedy Medal to Past-President J. G. Sullivan of Winnipeg, the Duggan Medal and Prize to P. L. Pratley of Montreal, the Gzowski Medal to David Boyd of Lachine and the Plummer and Leonard Medals to C. R. Whittemore of Montreal and L. S. Weldon of Tanganyika respectively.

Past-President H. H. Vaughan took the chair at the luncheon which followed, and the gathering was addressed by James H. Herron, President of the American Society of Mechanical Engineers, who spoke on social progress as affected by mechanical advancement, the dispersion of education and culture, and the increased responsibilities now imposed upon government. He was followed by H. V. Potter, representing the Society of Chemical Industry, who told of the efforts being made in Britain to co-ordinate and link in some central organization the work of three great chemical societies, the Society he represented, the Institute of Chemistry, and the Chemical Society, the latter being mainly interested in problems of pure science.

After luncheon the delegates adjourned to an 'Overseas Session,' at which three papers were presented by British contributors. General Mowat, secretary of the Institution of Mechanical Engineers, spoke on British Engineering Societies and Their Aims; Hugh Beaver dealt with Industrial Zoning and predicted the eventual establishment of centralized control of all forms of transport in Great Britain; and Johnstone Wright, chief engineer of the Central Electricity Board, described the construction and operation of the Grid system of main electrical distribution in Great Britain. Active discussion followed on all these papers. Canadians were particularly interested to note that the British Grid system was designed, constructed and operated under the supervision of outstanding professional experts, who were in no way subject either to governmental direction or political interference.

The first day of the meeting closed with a Semicentennial Ball in the Windsor Hall, at which the guests were received by President and Mrs. Desbarats. The decorations of the hall and of the Rose Room, where supper was served, featured the beaver-emblem of The Institute, and a striking record of names of the forty-seven Past Presidents of The Institute was displayed as a frieze round the room.

On Wednesday, June 16th, the technical sessions of the meeting began. The delegates divided into two sections to hear papers on such diverse subjects as the Utilization of Canadian Coals, the Use of Electric Power in Metallurgy, Electric Relaying, and Welding. At the luncheon which followed, the Hon. C. D. Howe presided, the guest speaker being A. C. Gardner, chief engineer of the Clyde Navigation Trust, Glasgow, Scotland. Mr. Gardner gave a fascinating history of the Clyde's development over the last two hundred years.

He was to have been followed by Mr. Harrison P. Eddy, whose untimely death was referred to by the chairman. Fortunately Mr. Eddy had prepared excellent notes of his address, and these were impressively presented to the meeting by F. S. B. Heward. In this message, which so unexpectedly proved to be his last, Mr. Eddy traced the probable sociological results of the far-reaching developments now taking place along engineering lines, holding that mass production will be extended to many more industries than at present; that conditions of agricultural production will change due to the adoption of methods of control and mechanization, and that these factors will inevitably lead to a reduction in the work-time required to satisfy the demands of the public. "What will be the result," asked Mr. Eddy, "of providing the resulting surplus of spare time?" In his view increased facilities for recreation and education must be available for everyone, a longer period of education for youth will be needed, and the development of scientific and literary occupations must be continued through adult life.

During the afternoon the technical sessions were continued, the papers treating of Concrete Construction, Freight Hauling in Undeveloped Territories, the Measurement of Stream Flow, the North Atlantic Air Service, and Modern Railway Motive Power.

The Banquet held in the evening was honoured by the presence of His Excellency the Governor-General, who was also the principal speaker. President Desbarats was in the chair, and was supported by Past-Presidents C. H. Mitchell, Arthur Surveyer and E. A. Cleveland. The former acted as toastmaster. The Governor-General's address, which appears on another page of this issue of the Journal, was followed by a toast to "Our Guests" proposed by Dr. Surveyer, the reply to which was given by Sir Alexander Gibb in his usual happy vein. The toast to "The Institute" was proposed in an eloquent speech by Mr. Edward P. Lupfer, representing the American Society of Civil Engineers, and was replied to by Past-President Cleveland. Greetings were heard from Sir Henry Barraclough, Past-President of the Institution of Engineers, Australia, speaking from Sydney, Australia; W. G. Sutton, President of the South African Institution of Engineers, speaking from Johannesburg; S. N. Ghose, Vice-President of the Institution of Engineers (India), Calcutta, and J. McGregor Wilkie, President of the New Zealand Society of Civil Engineers, speaking from Wellington.

The arrangement of the head table was unusual and most effective. Upon an elevated dais there had been placed a bank of peonies, white and pink, surrounding the beaver of The Institute worked in dark foliage and cutting a tree trunk of red peonies. Round this great mass of flowers sat the head table guests and officers of The Institute.

The proceedings were broadcast over the network of the Canadian Broadcasting Commission.

Thursday, June 17th, was devoted to a series of well organized visits to industrial and engineering works in and near Montreal, the tours being arranged so as to return in the afternoon in time for a Garden Party on the Campus of McGill University, which had been made possible through the courtesy of the University authorities. The gathering was addressed by Dr. W. H. Brittain, Acting Principal of the University, and afforded a pleasant opportunity for renewing acquaintanceships and comparing notes on the events of the day.

In the evening, the closing event of the Montreal celebrations was a very successful and well attended smoking concert in the Windsor Hall, held under the direction of C. C. Lindsay, at which President Desbarats took the opportunity of expressing to Mr. Busfield the appreciation of The Institute Council and members of The Institute at large, of the services of himself and the Semicentennial Committee of which he was chairman. This gratitude was indicated in a very practical fashion by the presentation of a silver cigar box.

During the Montreal meetings a number of events were arranged specially for ladies, including a tea and bridge, and a drive to Macdonald College and Senneville, which were well attended and greatly appreciated.

On the morning of the following day, Friday, June 18th, the visiting engineers and many Montreal members proceeded to Ottawa, where the celebrations were continued by a luncheon at the Chateau Laurier, afternoon tours of inspection to power plants, industrial establishments, government laboratories and buildings, and by a dinner in the evening. At the luncheon gathering, the presiding officer was J. G. Macphail, chairman of the Ottawa Branch, and the speaker was H. Gerrish Smith, vice-president of the Society of Naval Architects and Marine Engineers, New York, who gave an interesting historical resumé of the development of shipping, with particular reference to the contributions of the engineer to safety and comfort at sea.

In the evening, President Desbarats took the chair at a dinner where the members and guests were addressed by the Hon. C. D. Howe on Air Transport in Canada. Mr. Howe gave an account of the remarkable developments which are culminating in the establishment of a modern air line route across Canada. It was evident that before hearing Mr. Howe few of his listeners had realized the extent and scope of this great undertaking. The dinner was followed by a very enjoyable dance, which was the final function of the Semicentennial week of meetings and festivities.

On Saturday morning, officials of the principal Government Departments in Ottawa kindly received delegates who were interested in departmental work of an engineering character.

Those who were fortunate enough to be present agreed that the celebrations as a whole, and particularly the

Garden Party on McGill University Campus—June 17th, 1937.

Proceedings at the opening session and at the banquet were impressive as a demonstration of the solidarity of The Institute, its position among the engineering societies of the world, and its friendly relations with sister organizations on this continent, in Europe, and in the other countries of the British Commonwealth of Nations.

Our visitors from overseas and from the United States were most kind in their many expressions of appreciation of the welcome they received and the manner in which the various functions were conducted.

All arrangements were carried out by the Semicentennial Committee whose membership follows:

| | | |
|---|---|---|
| Montreal — | A. Cousineau, A.M.E.I.C. | Executive |
| | J. M. Fairbairn, A.M.E.I.C. | Publicity |
| | R. H. Findlay, M.E.I.C. | Executive |
| | W. McG. Gardner, A.M.E.I.C. | Hotel |
| | F. S. B. Heward, A.M.E.I.C. | Reception |
| | C. C. Lindsay, A.M.E.I.C. | Smoking Concert |
| | H. Massue, A.M.E.I.C. | Branch Delegates Conference |
| | G. Midgley, A.M.E.I.C. | Visits |
| | C. K. McLeod, A.M.E.I.C. | Dance |
| | J. F. Plow, A.M.E.I.C. | Registration |
| | T. C. Thompson, A.M.E.I.C. | Technical Sessions |
| Ottawa — | A. Ferrier, A.M.E.I.C. | Luncheon |
| | W. H. Munro, M.E.I.C. | Visits |
| | J. L. Rannie, M.E.I.C. | Dinner Dance |
| | A. K. Hay, A.M.E.I.C. | Chairman |
| | J. L. Busfield, M.E.I.C. | Chairman |

As regards attendance, it may be said that the total registration of members, ladies and guests was fully as large as anticipated. Some four hundred and fifty attended the Banquet in Montreal. At the luncheons at Montreal and Ottawa the attendance was from two hundred and seventy-five to three hundred and fifty. Two hundred and fifty were present at the garden party, three hundred at the smoking concert, and approximately the same number at the dinner and dance at Ottawa.

## Special General Meeting of The Institute

**June 21st, 1937**

The Special General Meeting of The Institute, notice of which was published on page 257 of the May issue of The Engineering Journal, was duly convened at ten a.m. on Monday, June 21st, at Headquarters, Vice-President J. A. McCrory, M.E.I.C., in the chair. Thirty-nine corporate members were present.

The Secretary having read the notice calling the meeting, the chairman stated that the objects of the meeting were as set forth in the notice, and that discussion would be in order.

Mr. Challies enquired whether any of the petitioners for the meeting were present.

Gordon McL. Pitts, A.M.E.I.C., as one of the petitioners, stated that the meeting was intended to provide an opportunity for the ordinary membership to express their wishes or thoughts. Since it was found impossible to make arrangements exactly in accordance with the intentions of the original petitioners, the present meeting did not fulfil the purpose for which it was called. He and his fellow petitioners, however, had held an informal meeting of their out-of-town representatives during the Semicentennial week at which there had been a very satisfactory discussion and very interesting points had been brought out.

There being no further discussion, J. L. Busfield, M.E.I.C., moved the adjournment of the meeting. His motion having been seconded by Mr. Gordon McL. Pitts, was carried unanimously.

The proceedings terminated at 10.17 a.m.

R. J. Durley,
*Secretary.*

## The Recent Ballot on Amendments to The Institute By-laws

At its meeting on May 28th, the attention of Council was drawn to certain statements which are reported to have been made at recent meetings, and which purported to give information as to the result of the voting in each province. The Council accordingly directed me to ask the scrutineers whether such information existed, and in reply the following letter was received:

June 3rd, 1937.

The Secretary,
The Engineering Institute of Canada,
Montreal.

Dear Sir:—

In reply to your letter of May 31st, with reference to the results of the canvass of the ballot on amendments to the By-laws, we would say that we have no information further than is contained in our report to Council dated April 30th. *In particular we would say that we are unable to give any statement as to the totals of the vote by provinces, since this information was never obtained.*

Yours truly,
R. E. Jamieson, M.E.I.C.
J. B. D'Aeth, M.E.I.C.,
R. H. Findlay, M.E.I.C.,
*Scrutineers.*

This letter is now published, by direction of Council, for the information of the membership.

The report dated April 30th to which the scrutineers refer, will be found on page 256 of the May issue of The Engineering Journal.

R. J. Durley, *Secretary.*

## The Semicentennial Meetings

### Acknowledgments

The Semicentennial Committee gratefully acknowledges the help so generously provided by the following organizations, without which it would have been impossible to have conducted the Semicentennial in such a satisfactory manner:—

Contributions in Service or Material—
- City of Westmount—Floral decorations for head table for banquet.
- Anglin Norcross Ltd.—Construction of head table for banquet.
- Bell Telephone Co.—Communications requirements.
- Northern Electric Co.—Equipment.
- R.C.A. Victor Corpn.—Special record.
- Montreal Tramways Co.—Transportation.

Contributions to Semicentennial Fund—
- Babcock-Wilcox & Goldie-McCulloch Limited
- Canada Cement Co. Limited
- Canadian Car & Foundry Co. Limited
- Canadian General Electric Co. Limited
- Canadian Industries Limited
- Canadian Ingersoll-Rand Co. Limited
- Canadian National Railways
- Canadian Pacific Railway Company
- Canadian Westinghouse Co. Limited
- E. G. M. Cape and Company
- Combustion Engineering Corpn. Limited
- Dominion Bridge Co. Limited
- Dominion Engineering Works Limited
- Dominion Steel & Coal Corp. Limited
- Foundation Co. of Canada Limited
- Fraser Brace Engineering Co. Limited
- General Dredging Contractors Limited
- Montreal Engineering Co. Limited
- Montreal Light, Heat & Power Consolidated
- Montreal Tramways Company
- Northern Electric Co. Limited
- Power Corp. of Canada Limited
- Shawinigan Water & Power Company
- Steel Co. of Canada Limited
- Superheater Co. Limited

J. L. Busfield,
*Chairman.*

# Address of His Excellency the Governor-General of Canada, Lord Tweedsmuir, P.C., G.C.M.G., C.H., Hon.M.E.I.C.

**At the Semicentennial Banquet of The Engineering Institute of Canada, Montreal, June 16th, 1937**

I am honoured to be here tonight as your guest at your jubilee dinner, and to congratulate The Engineering Institute of Canada on fifty years of vigorous and fruitful life. Some time ago you honoured me by making me an Honorary Member of The Institute, a distinction of which I am very proud, for I have no knowledge of engineering to justify it. I have had a good many different professions in my life, and at different times I have had inclinations to many more. But I cannot ever remember wishing to be an engineer. I always felt that your world was a world quite beyond me. I admired it profoundly, but I admired it from afar, as the ignoramus admires the expert.

Most professions, it seems to me, are empirical things and deal largely in speculations and generalities. The business of a lawyer, for example, is to give practical application to general principles, but he is not dealing with an exact science. No legal doctrine is really precise in its application. The work of a doctor, too, must be largely experimental. As for the politician, the terms he uses can never be accurately defined—that is part of the fun of politics. Therefore in nearly every profession you have faddists and theorists. But the engineer is wholly different. He has to deal with hard facts. He knows that if he is not exactly right in his calculations he will be wholly wrong. That gives his mind, I think, a clearness and precision which is not common in other walks of life. I have had the good fortune to know a fair number of eminent engineers, and I have always been struck by the masculine firmness of their intelligence. There are no vague patches, no loose ends in their methods of thought.

Your profession, gentlemen, has always been the foundation of any civilized society. You provide the basis, the physical basis, which makes government possible. That was so in the ancient monarchies of the East and especially in ancient Egypt. There were not many greater engineers in history than the Egyptians. The Greeks, it is true, were no engineers. They were interested more in the human mind than in the physical conditions of life. But they had to borrow a physical basis from their predecessors, and without these predecessors there would have been no Greek civilization. When you come to the Romans, the real makers of the world as we know it, we find that they were above all things a race of engineers. The Roman roads, the Roman aqueducts, the Roman bridges still stand to-day in the Old World as a memorial of a people who based their society firmly on engineering science.

Here, in Canada, the engineer is very much in the position of the ancient Romans. In the settled countries of Europe to-day I think one might say that nature has been largely conquered by the engineer. He has constantly to adjust and modify his science as new needs arise. But the initial problems have been solved. But here in this vast Dominion you have still the same kind of problem to face as the Romans had. You have to conquer space and you have to adapt landscape to human needs. Your profession must always be a matter of expansion and constant pioneering, and therefore a live profession. You have already had many great engineering achievements to your credit; your trans-continental railways, your harnessing of water powers are among the miracles of modern science.

But, gentlemen, I think your work has only begun. I am convinced that the future will hold for you still far greater triumphs than you ever contemplated. The future of the British Commonwealth depends largely upon applied science and now, when the old days of territorial expansion are over, you may fairly say that the engineer is the true empire-builder.

May I be allowed to say one word on a subject which concerns us deeply in Britain and which is of some importance to Canada. The beauty and dignity of Nature are among the chief assets which any country can possess. In a small, closely settled country, this beauty must be carefully preserved and it is most important to keep the balance between the aesthetic and the utilitarian point of view. The secret and subtle loveliness of the English countryside and of the Scottish Highlands can easily be ruined if the only consideration is utility.

Now, on this matter, it is important not to be pedantic. I have no patience with people who see in every modern development an outrage on nature. When railways were first started in England there was a loud outcry that the beauty of the countryside was gone. But nature has a wonderful power of absorbing human inventions. It was a foolish outcry, for it has added to its charm. It has proved the stability of nature, for it has absorbed the railways and made them a part of it.

The same I have no doubt will be true of the great arterial motor roads of the future. Take an achievement like the Forth bridge. I remember in my boyhood how people declared that such a bridge would ruin the amenities of the Firth of Forth. The exact opposite is the truth. These great piers, with the sea below them and the Highland hills as their background, have enormously added to the beauty and picturesqueness of Scotland because it has brought the human interest in touch with the mysteries of nature, just as the pyramids have added to the wonders of the Egyptian desert. In Switzerland the pylons marching down the countryside carrying electric power, so far from destroying the grandeur of the Alps have added to them by placing homely human interests in contrast to their immensity. It is necessary in these matters to get rid of shallow aesthetic fads and take a robust view of what constitutes the picturesque.

But at the same time the human construction must keep in some kind of harmony with nature. This is true even in Canada where you are dealing with nature in its wildest form. Even in Canada the engineer should also be something of an artist. As I have said, I think the introduction of a human interest does not spoil but rather dignifies any landscape. For example, I have been greatly impressed with the beauty in the west, of the grain elevators, with their white domes and towers, which carry the eyes from the immense prairie levels to the blue prairie sky. I do not suppose there was any conscious artistic purpose in the building of these elevators, but I can testify the result is excellent.

This morning I went for a trip around Montreal harbour and again was enormously impressed with the beauty of the elevators. They make a most dignified entrance and gateway to this great city. But there is one point of which I think the Canadian engineer should have some consciousness of his purpose, and that is in connection with bridges. Canada is a country of bridges, and the bridge is one of the most beautiful of human creations. I hope that your great profession will create bridges worthy of that august natural setting. Canada will be, and indeed Canada is already, the natural playground of North America, and those who visit us will demand beauty as well as usefulness.

Your profession, gentlemen, has a great mission, you have in your hands the furnishing of the material background of a great nation. You are the pathfinders, the roadmakers, the Cyclopean architects of a land whose horizons are not limited, and whose future no man can assess. I congratulate you most warmly upon a half century of brilliant achievement, and I am very certain that when you come to celebrate your centenary you will look back even upon this year of your jubilee as no more than a day of small things.

## Honorary Memberships Presented at Semicentennial Meeting

### Harrison Prescott Eddy, M.E.I.C.

A sketch of the career of Harrison P. Eddy, M.E.I.C., Past-President of the American Society of Civil Engineers, appears on page 593 of this issue of The Journal.

Mr. Eddy came to the Semicentennial Meeting to receive his Honorary Membership in person and died suddenly soon after his arrival in Montreal.

A man of high professional attainments, few engineers in North America were more greatly esteemed. His loss is deplored by a host of Canadian friends.

### Robert William Angus, M.E.I.C.

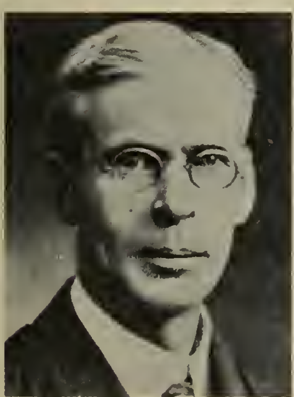
Robert William Angus was born in 1873 at St. Thomas, Ontario, and educated at the University of Toronto, graduating B.A.Sc. in 1897, and later receiving the degree of M.E.

His early engineering experience was with E. Leonard and Sons, London, Ontario, and in Pittsburgh and Cleveland, Ohio, where he was engaged in the design of automatic screw machines, steel plant equipment, and internal combustion engines.

In 1905 he was appointed Professor of Mechanical Engineering at the University of Toronto; he has occupied that position continuously since that time. He also practises as a consulting engineer and is a recognized authority on hydraulic problems, particularly those connected with surges and water hammer. He has done special consulting and investigating work for the City of Toronto and the Hydro-Electric Power Commission of Ontario.

Professor Angus' published works include, "Theory of Machines" (1915) and "Hydraulics for Engineers" (1931); he has presented many papers on his special branches of work before scientific and engineering societies.

He joined The Institute as a Member in 1921. He also holds membership in the Institution of Mechanical



R. W. Angus

G. H. Duggan

Engineers, the American Society of Mechanical Engineers (of which he was a Vice-President from 1924 to 1926), the American Water Works Association, and the Ontario Association of Professional Engineers (serving as President of that body in 1936).

### George Herrick Duggan, D.Sc., LL.D., M.E.I.C.

George Herrick Duggan, D.Sc., LL.D., M.E.I.C., the donor of the recently established Duggan medal and prize, was born in Toronto in 1862; graduated from the University of Toronto in 1883, and commenced his engineering career with the Canadian Pacific Railway Company. In 1886 he joined the staff of the Dominion Bridge Company, and was appointed chief engineer in 1891. In 1901 Mr. Duggan became assistant to the president of the Dominion Iron and Steel Company and the Dominion Coal Company, and was promoted to second vice-president and general manager of the Dominion Coal Company in 1904. In 1910 he returned to the Dominion Brigde Company as chief engineer, and later became general manager and vice-president, being appointed president in 1918. He held that office till 1936, when he resigned and became Chairman of the Board of Directors.

Mr. Duggan joined the Canadian Society of Civil Engineers as an Associate Member in March 1888 and was elected a Member in 1890. He served on Council for nine years, was vice-president for five years, and President in 1916. He was the recipient of the Sir John Kennedy Medal in 1931.

He is a vice-president of the Royal Bank of Canada, and director of numerous Canadian organizations, including the Steel Company of Canada, the Dominion Steel and Coal Corporation, the Montreal Trust Company and the Wayagamack Pulp and Paper Company.

Mr. Duggan is a Doctor of Science of the University of Toronto, and has received the honorary degree of LL.D. from both McGill and Queen's Universities. In 1936 he was elected an Honorary Member of the American Society of Civil Engineers.

Sir Alexander Gibb

The Hon. C. D. Howe

### Sir Alexander Gibb, G.B.E., C.B., F.R.S., M.E.I.C.

Sir Alexander Gibb, G.B.E., C.B., F.R.S., M.E.I.C., President of the Institution of Civil Engineers, has been the recipient of many honours, and has rendered to his country and to the public distinguished service, both in peace and in war time.

Born in Scotland in 1872, Sir Alexander started his professional career as a pupil of the late Sir John Wolfe Barry. He is now the senior member of the firm of Sir Alexander Gibb and Partners, and has held such appointments as consulting engineer to the Admiralty for the Singapore Naval Base; chief engineer for ports construction to the British Armies in France and Belgium, 1916-1918; civil engineer-in-chief to the Admiralty, and chief engineer for the reconstruction of the ports of Belgium (with rank of Brigadier-General), 1918-1919. In 1931-1932 he came to Canada and reported to the Dominion Government on the harbours of Canada, his report being published as the National Ports Survey in 1932.

Sir Alexander is a member of many engineering and learned societies, and his firm, which is of acknowledged eminence, is actively engaged in all forms of civil engineering. He joined The Institute as a Member in 1932.

### The Hon. C. D. Howe, M.P., M.E.I.C.

The Hon. C. D. Howe, M.E.I.C., was born at Waltham, Mass., in 1886. He graduated from the Massachusetts Institute of Technology in 1907, and was subsequently assistant in the structural engineering department of the same university. From 1908 until 1913 he was professor of civil engineering at Dalhousie University, Halifax, and also acted as a consulting engineer on important factory and warehouse structures. From 1913 until 1916 Mr. Howe was chief engineer of the Board of Grain Commissioners of Canada and was in charge of the design and construction of terminal grain elevators at Saskatoon, Moose Jaw, Calgary and Vancouver. In 1916 he established the firm of C. D. Howe and Company, consulting engineers, at Port Arthur, Ont., and since that time has designed and superintended the construction of many large grain elevators. He also surveyed the grain handling situation in the Argentine for the government of that country. Mr. Howe has travelled extensively, studying world trade, particularly factors affecting the grain business, becoming a recognized authority on that class of engineering work.

S. J. Hungerford

Hon. Grote Stirling

In 1935 he was elected to Parliament as Liberal Member for Port Arthur, and on the formation of the Mackenzie King government he entered the Cabinet as Minister of Railways and Canals and Minister of Marine. Under his direction these important departments have now been consolidated and enlarged, resulting in the formation of the new Department of Transport over which he presides as Minister. Mr. Howe joined The Institute as a Member in 1922.

### Samuel James Hungerford, M.E.I.C.

Samuel James Hungerford, M.E.I.C., was born at Bedford, Quebec, in 1872. His first railway work was as machinist apprentice with the Canadian Pacific Railway at Farnham. From 1891 to 1910, he remained with the Canadian Pacific Railway and held such positions as master mechanic of the western division, with headquarters at Calgary, and superintendent of the large locomotive shops at Winnipeg. In 1910 Mr. Hungerford entered the service of the Canadian Northern Railway, becoming superintendent of rolling stock with headquarters first at Winnipeg and later at Toronto. Following the organization of the Canadian National Railways, he was appointed in November 1917 general manager of the eastern lines, and in the following year became vice-president and general manager. In 1923 he was appointed vice-president in charge of operation, maintenance and construction, and in 1934 the Board of Trustees, named to administer the affairs of the railway, appointed him as President. In 1936 he became chairman of the new Board of Directors of the Canadian National Railways.

Mr. Hungerford joined The Institute as a Member in 1919.

### The Hon. Grote Stirling M.E.I.C.

The Hon. Grote Stirling, M.E.I.C., was born at Tunbridge Wells, England, in 1875, and was educated at University College School, London, and the Crystal Palace School of Engineering, graduating from the latter institution in 1895. Following graduation he was for several years occupied in railway work as assistant resident engineer and resident engineer with the Midland and Great Northern Joint Railways, and in 1907-1911 he was in private practice in Norfolk, England. Coming to this country in 1911, Mr. Stirling was resident engineer during 1912-1913 on the construction of the Black Mountain Water Company's main irrigation system at Kelowna, B.C., and has since been engaged in private practice in that part of the country.

In 1901 Mr. Stirling was elected an Associate Member of the Institution of Civil Engineers, and joined The Institute as a Member in 1927.

He was first elected to Parliament in November, 1924, when the seat at Yale, B.C., was vacated by the death of J. A. McKelvie, and he was re-elected in the three succeeding general elections of 1925, 1926 and 1930. In 1934 he was appointed Minister of National Defence and acting Minister of Fisheries in the Bennett Cabinet.

### Jacques Rabut

**Chevalier de la Légion d'honneur, Croix de Guerre**

M. Jacques Rabut, whose age is fifty-two, graduated from the Ecole Nationale des Ponts et Chaussées in 1909. and is a prominent Member of the Société des Ingénieurs Civils de France. He is at the head of the firm Société Ch. Rabut et Cie, in Paris, which carries on an extensive practice in consulting engineering.

During the winter of 1934 he visited Canada and gave a series of twelve lectures to the graduates of the Ecole Polytechnique, Montreal. The series dealt with the Technique of Great Modern Public Works, and its scope may be judged from the title of the opening lecture which was "The Scientific and Industrial Evolution of the Art of Construction." M. Rabut described construction methods used in twelve of the principal public works carried out in Europe during the past decade, and he was good enough to repeat one of these lectures in English at a meeting of the Montreal Branch of The Engineering Institute of Canada.

## Results of May Examinations of The Institute

The report of the Board of Examiners, presented at the meeting of Council held on May 28th, 1937, certified that the following candidates, having passed the examinations of The Institute, have satisfied the examiners as regards their educational qualifications for the class of membership named:

Schedule "B"—For admission as Junior:

John Jomini, Grand'Mere, Que.

J. Philias Villemure, S.E.I.C., Grand'Mere, Que.

## OBITUARIES

### Harrison Prescott Eddy, Hon.M.E.I.C.

It is with the deepest regret that we have to announce the death at Montreal on June 15th, during the Semi-centennial Meeting of The Institute, of Harrison Prescott Eddy, Hon.M.E.I.C., a distinguished leader of the profession and a man of acknowledged eminence in sanitary engineering. Mr. Eddy had come to Montreal to receive an Honorary Membership in The Institute, and to be one of the guest speakers at the celebrations. He had driven from Boston with his family and was stricken with a heart attack not long after his arrival.

Harrison Prescott Eddy, Hon.M.E.I.C.

Mr. Eddy had been outstanding in civil engineering for forty years; in his special field he was probably the most eminent American practitioner of his day. Born in Millbury, Mass., on April 29th, 1870, his early training and practical experience was gained in New England, where he took up sanitary engineering work immediately upon graduation from the Worcester Polytechnic Institute in 1891. In that year he was appointed superintendent of the sewage treatment plant at Worcester, and the following year became superintendent of the sewer department of the city, work which included entire charge of design and construction.

Mr. Eddy continued at Worcester until 1907, when he went into private practice with Leonard Metcalf under the firm name of Metcalf and Eddy. That association was dissolved by Mr. Metcalf's death in 1926, but the firm name was continued. As a member of the firm of Metcalf and Eddy, he acted as consultant on problems of water supply, sewage and waste disposal for nearly one hundred cities, including Chicago, Cincinnati, Buffalo, Dayton, New Orleans, Detroit and Washington. Outstanding among these undertakings was his work on the design of the sewerage system of Louisville, which brought him national recognition, and his study of sewage disposal and water supply for Milwaukee. He also served in an individual capacity as a member of numerous boards and commissions, most notable of which was the engineering board of review of the Sanitary District of Chicago. In recent years he was a member of the P.W.A. board of review.

Mr. Eddy was widely known as the co-author of a standard work on American Sewerage Practice and Sewerage and Sewage Disposal, and many technical papers and reports also have appeared under his name.

He took an active part in the affairs of technical and professional societies, including the American Society of Civil Engineers and the Boston Society of Civil Engineers, of which organizations he was a past-president; the American Water Works Association, the American Institute of Consulting Engineers and the American Public Health Association.

Mr. Eddy became a Member of The Engineering Institute of Canada on March 23rd, 1926.

### Charles Louis Arcand, A.M.E.I.C.

Regret is expressed in placing on record the death in Montreal on March 31st, 1937, of Charles Louis Arcand, A.M.E.I.C. Mr. Arcand was born at Three Rivers on November 22nd, 1880, and graduated from the Classical and Business College of Three Rivers in 1899. In 1900 he was appointed by the Department of Public Works of Canada to the district engineer's office in Three Rivers, and in 1907 became assistant engineer for the Department, which position he held up to the time of his death.

Mr. Arcand joined The Institute as an Associate Member on June 24th, 1919.

### Charles Bruce Daubney, A.M.E.I.C.

It is with deep regret that we place on record the death at Norwood, Mass., on May 12th, 1937, following a long illness, of Charles Bruce Daubney, A.M.E.I.C., of Ottawa. Mr. Daubney was returning to Ottawa from the southern United States, where he had been at a health resort.

Born at Cummings' Bridge, Ontario, on November 28th, 1889, he graduated from McGill University in 1910, with the degree of B.Sc. Following graduation he was instrumentman on the Fort William terminals, and subsequently was with John S. Metcalf Company Limited, engaged on elevators at Montreal and Saint John, N.B. In 1913-1914 Mr. Daubney was demonstrator in civil engineering at McGill University. In 1915 he joined the Department of Railways and Canals, and was assigned to harbour terminal construction at Port Nelson. During the World War he enlisted with the Canadian Expeditionary Force, holding the rank of lieutenant with the engineers. On returning to the Department of Railways and Canals following his discharge, he was appointed engineer for the St. Lawrence waterways. In 1924 Mr. Daubney was promoted to the head office staff of the chief engineer of the Department, and a few years later became general assistant engineer, an office he still held after the Department of Railways and Canals became part of the newly created Department of Transport.

Charles Bruce Daubney, A.M.E.I.C.

Mr. Daubney joined The Institute as an Associate Member on March 21st, 1916.

### Richard Adams Davy, M.E.I.C.

It is with deep regret that we place on record the death at Ottawa on May 1st, 1937, of Richard Adams Davy, M.E.I.C., one of the original members of the Canadian Society of Civil Engineers.

Born at Penzance, Cornwall, England, Mr. Davy was educated there and in London, commencing the study of civil engineering in 1870 under the borough engineer of Penzance. Coming to Canada in 1873, Mr. Davy made a number of mine surveys on the north shores of Lake Superior, and in 1875 was on the Canadian Pacific Railway's survey between Finmark and Lake of the Woods. With H. I. Mortimer he laid out the Fort Francis locks. In 1881 he was engaged on the location and construction of the Canadian Pacific Railway Kingston-Pembroke line, following which he was made division engineer in charge of the construction of the 25-mile line between Hawk Lake and Kenora. His division was later extended to Eagle Lake, a total distance of 67 miles. Upon completion of the railway between Port Arthur and Winnipeg, Mr. Davy made an exploratory survey for the line between Richelieu and Lennoxville, Que., and in 1887 went to Riviere du Loup to revise the location of the Temiscouata Railway. In the following year he was made chief engineer on the construction work, and during this time also ran a preliminary line for a railway between Edmundston, N.B., and Moncton, a distance of 250 miles. In 1892 Mr. Davy was engaged in Exchequer Court cases and was sent by the Department of Railways and Canals to supervise the boring for the projected Prince Edward Island tunnel. In 1894 and 1895 he assisted in irrigation construction work between Gleichen and Lethbridge, Alta., and in 1896 made a joint report with C. H. Keefer for the Ottawa main drainage. In the following year Mr. Davy was appointed assistant engineer on the enlargement of the Iroquois canal. He was then stationed in the district office of the Department of Railways and Canals until 1901 when he took charge of the construction on the Simcoe-Balsam Lake division of the Trent canal. Some years later Mr. Davy had charge of the construction of the Bank Street subway in Ottawa for the Grand Trunk Railway, and then made a survey for a railway between Meaford and Owen Sound. In 1907 he was given charge of the Buckborn dam and bridge and in 1908 went to Lindsay to supervise the reconstruction of the locks, dams and bridge there, being transferred to the Heeley Falls section in 1910. Mr. Davy retired about twelve years ago, and has since lived in Ottawa.

Richard Adams Davy, M.E.I.C.

Mr. Davy became a Member of the Canadian Society of Civil Engineers on its foundation on January 20th, 1887. Together with the late Colonel W. P. Anderson, he took an active part in the discussions in Ottawa which led to the participation of many Ottawa engineers in the formation of the Society. He was greatly interested in its early history, and his reminiscences form a valuable record of its establishment.

### John Smythe Hall, A.M.E.I.C.

We regret to announce the death at Montreal on May 8th, 1937, of John Smythe Hall, A.M.E.I.C.

Mr. Hall was born at Montreal on January 27th, 1894, and graduated from McGill University in 1914 with the degree of B.Sc. Following graduation he joined the staff of the Canadian Pacific Railway Company, and had only been in that service for a short time when war broke out. He enlisted in the 148th Battalion, C.E.F., in 1915, but was later transferred to the Light Railway Operating Company, and afterwards to the Royal Tank Corps, with which unit he served in France until the end of the War. Returning to Canada, Mr. Hall resumed his connection with the Canadian Pacific Railway, and with the exception of two years with the Franklin Railway Supply Company, served with that company until the time of his death. He was last stationed at Calgary.

Mr. Hall joined The Institute as a Student on December 14th, 1912, and became an Associate Member on April 18th, 1922.

### Lewis W. Toms, A.M.E.I.C.

Members of The Institute will learn with regret of the death at Victoria, B.C., on May 15th, 1937, of Lewis William Toms, A.M.E.I.C., a member of very long standing.

Mr. Toms was born in England at Combe Martin, North Devon, on December 25th, 1857, and was educated at Marlborough College and at the Crystal Palace School of Engineering. In 1877-1879 he was with Whitehead and Company, torpedo manufacturers, Fiume, Austria, and subsequently took a course in civil engineering at Glasgow University. From 1881 to 1884 Mr. Toms was with Mirrlees, Watson and Company, Glasgow, and in 1885 went to Australia, where he was engaged on the erection of a sugar mill plant for the Colonial Sugar Refining Company. He returned to England, and in 1888 went to Kauai, Hawaiian Islands, where he erected a cane sugar diffusion plant for the MacKee Sugar Company. In the same year Mr. Toms came to Canada, and entered the drawing office of Miller Bros. and Mitchell, Montreal, becoming a member of the firm of Miller Bros. and Toms in 1889. In the late 90's, Mr. Toms went to Vancouver and conducted prospects and inspection for eastern mining interests in the Cariboo and Kootenay districts. In 1904 he returned to fruit-farming on Vancouver Island. During the War, Mr. Toms worked as a shell inspector in Vancouver and Victoria.

Lewis W. Toms, A.M.E.I.C.

He became an Associate Member of The Institute (then the Canadian Society of Civil Engineers) on November 14th, 1889.

### Leslie Lucas, A.M.E.I.C.

Regret is expressed in placing on record the death at Montreal on June 23rd, 1937, of Leslie Lucas, A.M.E.I.C.

Mr. Lucas was born at Annan, Dumfrieshire, Scotland, on August 13th, 1896, and was educated at the Royal Technical College, Glasgow. He served a five-year apprenticeship with Mavor and Coulson Limited, Glasgow, and served with the Imperial Army from 1914 to 1919, first with the Seaforth Highlanders, and holding the rank of Captain with the Highland Light Infantry after 1917. Coming to Canada in 1923, Mr. Lucas was on the staff of Fraser Brace Limited, Montreal, as a draughtsman, and in 1924-1926 was superintendent of plant and transmission lines with the Great Northern Power Company at Indian Chutes, Ont. In the latter year he became plant manager for the Northern Canada Power Company Limited, Timmins, Ontario, and in 1929 was connected with the Sun Life Assurance Company, Montreal. Mr. Lucas then joined the staff of the Northern Electric Company, Montreal, and was with that firm at the time of his death.

Mr. Lucas joined The Institute as a Junior on January 27th, 1925, and became an Associate Member on February 10th, 1928.

### Coote Nisbitt Shanly, M.E.I.C.

Deep regret is expressed in placing on record the death at Kingston, Ont., on May 5th, 1937, of Coote Nisbitt Shanly, M.E.I.C.

Mr. Shanly was born at Montreal on January 29th, 1889, and following two years at McGill University was from 1905 until 1908 with the Canadian Pacific Railway Company, the Dominion Bridge Company, and the Prince Edward Island Railway. In 1909 Mr. Shanly was in charge of a plane table party for the Irrigation Department of

Coote Nisbitt Shanly, M.E.I.C.

the Canadian Pacific Railway, and in 1910 was in charge of a railway location party for the Kananaskis Coal Company. From 1911 until 1912 Mr. Shanly was in the city engineer's office, Vancouver, and in 1913-1914 was engaged on the design of concrete railway structures for the Canadian Northern Ontario Railway. He served in England, France and Salonika with the Royal Engineers from 1914 to 1918, in the latter year commanding the railway survey and reconnaissance section, R.E., handling all railway location for the British Salonika Force. Returning to Canada in 1919, Mr. Shanly was connected with the Department of Soldiers Civil Re-establishment in the Montreal Retraining Centre. He joined the engineering staff of Price Brothers and Company Limited in 1920, subsequently being assistant resident engineer for the Kenogami paper mills, resident engineer on the hydro-electric development at Chute aux Galets, in charge of preliminary studies for mill and town sites, in charge of construction of the hydro-electric development at Chicoutimi, and town manager at Kenogami. Latterly Mr. Shanly was engaged on insurance work for the Imperial Life Assurance Company, at Quebec, and as manager at Kingston, Ontario.

Arthur Langley Mudge, M.E.I.C.
Whose Obituary appeared in the May, 1937, issue of The Journal.

Mr. Shanly became a Student of The Institute on April 17th, 1909, was elected a Junior on March 11th, 1913, an Associate Member on May 25th, 1920, and a Member on June 7th, 1924. He took an active interest in Institute affairs, and was chairman of the Saguenay Branch in 1925.

### Silfroy Joseph Fortin, M.E.I.C.

It is with regret that we announce the death at Montreal on May 17th, 1937, of Silfroy Joseph Fortin, M.E.I.C.

Mr. Fortin was born at St. Sebastien, Iberville county, Que., in 1867 and graduated from the Ecole Polytechnique, Montreal, in 1889. Following graduation, he was, until 1899, engaged on structural steel design, working in New York, Philadelphia and Chicago, in turn with Levering and Garrigues, the American Bridge Works, the Riverside Bridge Works, and C. O. Brown, New York. He next spent two years in Honolulu, then two years in Japan and China, subsequently becoming resident engineer and representative of Milliken Brothers of New York City, in Mexico. From 1914 until 1918 Mr. Fortin was employed by the Federal Government at Ottawa to supervise the building of bridges and jetties, as well as a number of hydraulic projects throughout the Dominion. He joined the city of Montreal Public Works Department in 1918 as Deputy Director of Public Works, and in 1922 was appointed Deputy Chief Engineer and chairman of the Techincal Commission of Montreal, which body he originated. Among his achievements may be named the supervision of the building of an arsenal and drydocks for the Russian government at Port Arthur, and the Post Office, Marine and Public Works buildings, the Legislative Palace and the National Theatre in Mexico City for the Mexican government. He was the author of two monographs, one dealing with the problems of foundations in the volcanic lava at Mexico City, and the other on the organization and functions of a town planning commission for the Island of Montreal.

Mr. Fortin became a Member of The Institute on December 21st, 1915, and was made a life member on June 12th, 1936.

## PERSONALS

W. H. Stuart, M.E.I.C., has resigned from his position as inspecting engineer for the Mines and Geology Branch of the Department of Mines and Resources at Ottawa, and has accepted an appointment with Mr. John E. Hammell in the mining industry. Mr. Stuart's home address will be at 7 High Park Boulevard, Toronto, Ontario.

J. F. McDougall, A.M.E.I.C., formerly highways engineer with the Department of Public Works, Alberta, is on the staff of McDougall and Secord Limited, Edmonton, Alta. Mr. McDougall graduated from the University of Alberta in 1930 with the degree of B.Sc., and obtained that of M.Sc. from McGill University in 1931, and following graduation entered the service of the Alberta Department of Public Works.

S. J. Hungerford, M.E.I.C., chairman of the Canadian National Railways, Montreal, has been named president of Trans-Canada Air Lines, and two other members of The Institute have been appointed provisional directors of the Board: J. A. Wilson, M.E.I.C., Controller of Civil Aviation, Department of Transport, Ottawa, and Lieutenant-Commander C. P. Edwards, O.B.E., A.M.E.I.C., Chief of Air Services, Department of Transport, Ottawa.

J. Hastie Holden, A.M.E.I.C., has been appointed manager of the Geo. W. Reed and Company Limited, Montreal. He was formerly sales manager for the company. Mr. Holden graduated from McGill University in 1923 with the degree of B.Sc. and subsequently became assistant to the plant engineer of the Northern Electric Company. In 1924 he joined the staff of the company with which he is now connected.

S. S. Colle, A.M.E.I.C., of Air Conditioning Engineering Company, Montreal, has moved his office to 2040 Union Avenue. Mr. Colle organized this company during 1936 to design and contract for the installation of ventilation, heating, humidification and air conditioning work. Mr. Colle was principal assistant to the late Frederick B. Brown, M.E.I.C., consulting engineer, up to 1932, and was engineer with the Beauharnois Light, Heat and Power Company from 1932 to 1936.

W. D. Black, M.E.I.C., president of the Otis-Fensom Elevator Company Limited, Hamilton, Ontario, has been elected first vice-president of the Canadian Manufacturers' Association. Mr. Black was chairman of the Hamilton branch of the Association in 1929-1931, and for several years was chairman of the Commercial Intelligence Committee. In 1934, as chairman of the Association's Industrial Relations Committee, he was appointed employers' delegate to the International Labour Conference in Geneva. Mr. Black is a director of the Bank of Canada.

A. H. Harkness, M.E.I.C., consulting engineer, Toronto, was the recipient of the honorary degree of Doctor of Engineering from the University of Toronto recently. Mr. Harkness graduated from the University of Toronto in 1895, returning for the degree of B.A.Sc. in 1897. After graduation he spent some three years in an architect's office, and then joined the designing staff of the Canada Foundry Company in their steel and bridge division. He remained with this company for eight years, holding in the latter years the position of assistant chief engineer. In 1910 he commenced consulting practice in the city of Toronto, and his work since that date has made an outstanding contribution to Canada's growth. The structural features of important buildings from Vancouver to Halifax pay tribute to his ability in that branch of engineering. Mr. Harkness, who was a vice-president of The Institute in 1932, received the Sir John Kennedy Medal, the highest honour which The Institute can bestow, in 1936.

Karel R. Rybka, A.M.E.I.C., was the recipient of the degree of D.Sc. at a convocation held recently at the College of Engineering (Technische Hochschule) in Prague. Dr. Rybka graduated from this college in 1923 in mechanical engineering and was subsequently for three years connected with diverse engineering works in Europe. Since 1928, when he came to Canada, he was on the staff of Walter J. Armstrong, consulting engineer in Montreal and Toronto, except for a short period devoted to private practice, and during the last three years was in charge of the Toronto office of the firm.

M. D. Stewart, A.M.E.I.C., has resigned his position as resident engineer with the Seigniory Club Community Association Limited, Seigniory Club, Que., to become town engineer for the town of Mount Royal, Que. Mr. Stewart graduated from the University of Toronto in 1922 with the degree of B.A.Sc. and during the following year was with Bremner Norris and Company Limited. In 1923 he was for a time inspector for MacVicar and Heriot on the new Caron Building, Montreal, becoming assistant engineer with Price Brothers and Co. Limited at Chicoutimi in 1924. In 1929 Mr. Stewart joined the staff of the Foundation Company of Canada, and in 1930 became connected with the Seigniory Club Community Association Limited.

C. H. Oakes, A.M.E.I.C., is now in the designs office at Woolwich Arsenal, England. Mr. Oakes attended Liverpool University from 1910 to 1915, and was subsequently until 1919 an engineer officer in the Royal Naval Transport Service. From 1919 until 1922 he held the same rank in the Merchant Service. In 1924-1927 Mr. Oakes was resident engineer for Meccano Limited, at Liverpool and Paris, and coming to Canada in the latter year, he became system operator at the Quebec terminal of the Shawinigan Water and Power Company. He was later resident engineer, and works manager with Canadian Industries Limited, and in 1930 joined the staff of the Boiler Inspection and Insurance Company of Canada as engineer and surveyor.

Major A. R. Ketterson, D.S.O., A.M.E.I.C., succeeds Phillips B. Motley, M.E.I.C., as engineer of bridges of the Canadian Pacific Railway Company. Major Ketterson, who is an Associate of the Royal Technical College, Glasgow, entered the service of the Canadian Pacific Railway as bridge inspector in the chief engineer's department, Montreal, in 1907. In 1910 he was engaged on work as a structural draughtsman of bridges in the same department, and in 1912 was appointed assistant engineer, holding this position until 1916 when he went overseas, where he served with distinction and was awarded the D.S.O. On demobilization Major Ketterson returned to the service of the Canadian Pacific Railway, and was appointed to the chief engineer's department, and in 1928 became assistant engineer of bridges.

W. P. Near, M.E.I.C., formerly city engineer of London Ont., and more recently with the motor vehicles branch, Department of Highways, Ontario, has been appointed a commissioner on the Ontario Municipal Board. Mr. Near graduated from the University of Toronto in 1903 with the degree of B.A. and in 1907 received that of B.A.Sc. from the same university. Following graduation he was employed on surveys and track revisions for the Temiskaming and Northern Ontario Railway, and in 1909 joined the engineering staff of the Works Department, Toronto, in the main drainage office, later being appointed engineer in charge of trunk sewer construction. Mr. Near was appointed city engineer of St. Catharines in 1913, which position he held until he received a similar appointment in London in 1923. In 1932 he resigned to become manager of the Toronto division of the Supertest Petroleum Corporation, and two years later accepted the position which he now relinquishes.

### Phillips B. Motley, M.E.I.C., Retires

Phillips B. Motley, M.E.I.C., engineer of bridges for the Canadian Pacific Railway, concluded forty-five years of service with the company when he retired on June 30th, 1937.

Born in Calcutta, India, Mr. Motley completed his general and engineering education in England, and joined the engineering department of the Canadian Pacific Railway Company at Montreal in 1892. He occupied the positions of draughtsman and inspector of bridges both in the shops and during erection until 1903 when he became assistant engineer in the department. In 1908 he was made assistant engineer of bridges, and on June 1st, 1911, received the appointment from which he has now retired. Among the more important bridges for which Mr. Motley has been responsible may be mentioned the Lethbridge viaduct, the Edmonton City bridge, the crossings of various large rivers on the prairies such as at Saskatoon, Outlook, Nipawin and Winnipeg, besides the bridge at Galt, Ontario, and the bridge over the St. Lawrence river near Montreal, which was reconstructed to allow for double tracks, and the Saint John, N.B. cantilever bridge. There were many others of lesser magnitude and of difficult construction, particularly in the Rocky and Selkirk Mountains and the North shore of Lake Superior.

Mr. Motley is a member of the Institution of Civil Engineers, the American Society of Civil Engineers, and the American Railway Engineering Association.

J. W. Orrock, M.E.I.C., for the past fifteen years engineer of buildings for the Canadian Pacific Railway Company, with headquarters at Montreal, has recently retired. Mr. Orrock's retirement comes after forty-six years' service with the Canadian Pacific Railway. He joined the company in 1891 as draughtsman in the chief engineer's office at Montreal, and in 1910 became chief draughtsman. In 1912 he was appointed division engineer at North Bay, and later was promoted to principal assistant engineer at Montreal, and attained the position from which he now retires in 1924. During his occupancy of this position, the engineering department has been in charge of the rebuilding of the Chateau Frontenac hotel at Quebec, the reconstruction and extension of the company's hotels at Banff and Lake Louise, the extension of the Palliser hotel at Calgary and the Empress hotel at Victoria, B.C., and the construction of the Royal York hotel at Toronto, as well as the construction of Digby and Kentville, N.S., and the Maritime hotels at Yarmouth, various station buildings such as those at Three Rivers and Park Avenue, Montreal.

Mr. Orrock is a member of The Engineering Institute of many years standing, having joined as an Associate Member on June 18th, 1896, and transferred to the class of Member on October 24th, 1907.

Jules Joyal, M.E.I.C, has joined the staff of the Consolidated Paper Corporation Limited, and will be located at Escoumains, where he will take charge of works to be in connection with the reopening of the Escoumains river for logging operations. Mr. Joyal is a graduate of the Ecole Polytechnique, having obtained the degree of B.A.Sc. in 1920. Following graduation he was for several years on survey parties for Price Brothers and Company Limited, the Lake Megantic Pulp Company, the Montmorency Lumber Company, and Henry Atkinson Reg'd., and in 1922 was division engineer in the Quebec Roads Department. In the same year he again became connected with Price Brothers and Company Limited, being engaged on survey and storage dam construction, the Kenogami mill extension, and as assistant logging engineer, until 1931 when he joined the staff of the Quebec Public Commission as engineer, from which position he has now resigned. Mr. Joyal has also resigned as secretary-treasurer of the Quebec Branch of The Institute, which office he has held for several years.

## Elections and Transfers

At the meeting of Council held on May 28th, 1937, the following elections and transfers were effected:

*Members*

DAVIES, Clarence Ebenezer, M.E., (Rensselaer Polytech. Inst.), Secretary, The American Society of Mechanical Engineers, New York, N.Y.

POITRAS, Paul E., B.A.Sc., C.E., (Ecole Polytechnique, Montreal), mech. engr., The Steel Company of Canada, Montreal, Que.

VAISON, Albert Felix, (Naval College, Brest), technical adviser, Dept. of National Revenue, Ottawa, Ont.

*Associate Members*

BOUCHARD, Jean, B.A.Sc., C.E., (Ecole Polytechnique, Montreal), city engr., St. Hyacinthe, Que.

HOGG, Thomas, (National Cert., Inst. Mech. Engrs.), dftsman., water rights branch, Dept. Natural Resources, Regina, Sask.

LAVERTY, Clarence Alvin, B.Sc., (Univ. of Alta.), elect'l. inspr., Boiler Inspection and Insurance Co. of Canada, Montreal, Que.

O'SHAUGHNESSY, Patrick Leo, B.Sc., (McGill Univ.), mill foreman, Canada Cement Co. Ltd., Belleville, Ont.

SNYDER, Beverly Wells, B.Sc., (Univ. of Alta.), engr., asst. to the vice-president, Can. Western Natural Gas. Light, Heat and Power Co. Ltd., Calgary, Alta.

*Juniors*

JOHNSON, Robert, M.Sc., (Univ. of Sask.), mech. and bridge dept., Dominion Bridge Co. Ltd., Lachine, Que.

*JOMINI, John Louis, (McGill Univ.), dfting. office, Consolidated Paper Corporation, Grand Mere, Que.

KIRKBRIDE, David Spencer, B.Sc., (Univ. of Sask.), 2229 Cornwall St., Regina, Sask.

McEWEN, Markland Neil, B.Sc., (Univ. of Man.), instrumentman, Dept. of Northern Development, Kenora, Ont.

NESBITT, William P., B.Sc., (Queen's Univ.), junior engr., Fraser Companies Ltd., Edmundston, N.B.

SHERWOOD, Benjamin H., B.Sc. (Univ. of Alta.), dftsman., engrg. dept., Imperial Oil Limited, Calgary, Alta.

*Transferred from the class of Associate Member to that of Member*

BURNS, Charles Henry McLeod, (Mt. Allison Univ.), asst. mgr., Canada Foundries and Forgings Ltd., Welland, Ont.

NICHOLSON, John Billington, B.A.Sc., (Univ. of Toronto), President, The Nicholson Company, Chrysler Building, New York, N.Y.

*Transferred from the class of Junior to that of Associate Member*

LLEWELLYN, Leopold William, B.Sc., (Univ. of Sask.), dftsman. and designer, Northwestern Iron Works Ltd., Regina, Sask.

*Transferred from the class of Student to that of Associate Member*

CAIRNCROSS, Alexander Thomas, B.Sc., (Queen's Univ.), technical adviser, dept. of engrg., Generalissimo's Staff, National Government of China, Chengtu, Szechwan, China.

LAING, David Alexander Shearer, B.Sc. (McGill Univ.), mech. engr., cable engrg. dept., Northern Electric Co. Ltd., Montreal, Que.

WISE, Alfred John, B.Sc., (McGill Univ.), inspr. and elect'l. engr., Canadian Underwriters Association, Montreal, Que.

*Transferred from the class of Student to that of Junior*

CHARLEWOOD, Charles Benjamin, B.Sc., (McGill Univ.), engr., Babcock-Wilcox & Goldie-McCulloch Ltd., Galt, Ont.

KELLAM, George Douglas, B.Sc., (Univ. of Man.), asst. engr., Canadian Western Natural Gas, Light, Heat and Power Co. Ltd., Calgary, Alta.

KERSHAW, Norman William, B.Sc., (Univ. of Sask.), asst. engr., Eagle Pencil Company, Drummondville, Que.

MANN, Oswald Nelson, B.Eng., (N.S. Tech. Coll.), asst. plant engr., Eagle Pencil Company, Drummondville, Que.

McKENZIE, Ralph Boynton, B.Sc., (Univ. of Alta.), elect'l. contracting, estimating, salesman, McKenzie Electric Ltd., Lethbridge, Alta.

ROMBOUGH, Joseph Harold Melville, B.Sc., (Queen's Univ.), tapping dept., Fittings Ltd., Oshawa, Ont.

STANLEY, Thomas Douglas, B.Sc., (Univ. of Alta.), M.Eng., (McGill Univ.), ap'ticeship engr., Calgary Power Co. Ltd., Calgary, Alta.

TWEEDDALE, Reginald Estey, B.Sc., (Univ. of N.B.), instrumentman on highway location, Arthurette, N.B.

*Students Admitted*

BLOCK, Jacob Benjamin, B.Eng., (McGill Univ.), 3511 Jeanne Mance St., Montreal, Que.

CAMPBELL, Gerald Arthur, (Univ. of N.B.), Fredericton, N.B.
EDSON, Ralph Everett, B.Eng., (McGill Univ.), 489 King St., Peterborough, Ont.
HOPKINS, Albert Parker Eugene, (Univ. of Toronto), senior asst., Ontario Geological Survey Party, Substation 98, Toronto, Ont.
LEMIEUX, Roland A., B.A.Sc., C.E., (Ecole Polytechnique, Montreal), 1702 St. Hubert St., Montreal, Que.
McNAUGHTON, Andrew Robert Leslie, (R.M.C.), Royal Military College, Kingston, Ont.
THOMPSON, James William Joseph, B.Eng., (N.S. Tech. Coll.), 7 Payzant Ave., Halifax, N.S.
WILKINSON, William C., (Univ. of N.B.), Campbellton, N.B.

*Has passed Institute's examinations.

# RECENT ADDITIONS TO THE LIBRARY

### Proceedings, Transactions, etc.

Society of Naval Architects and Marine Engineers: Transactions 1936.
Institution of Mining and Metallurgy: Transactions 1936.
Highway Research Board: Proceedings 16th Annual Meeting, 1936.

### Reports, etc.

*National University of Ireland:* Calendar, 1936.
*American Society of Civil Engineers:* Year Book 1937.
*International Association for Testing Materials:* 1937. Advance proofs of papers—Group A, Metals.
*American Institute of Electrical Engineers:* Year Book 1937.
*British Engineers Association:* Classified Handbook of members and their manufactures.
Welfare Work in Montreal, 1936.
*American Concrete Institute:* List of Members.
*University of Toronto, Faculty of Applied Science and Engineering:* Calendar 1937-1938.
*Lethbridge Northern Irrigation District:* 16th Annual Report, 1936.
*Civil Service Commission of Canada:* 28th Annual Report, 1936.
*Department of Lands and Mines, Alberta:* Annual Report 1936.
*Association of Ontario Land Surveyors:* Annual Report 1937.
*Canada, Dept. of Mines and Resources, Mines and Geology Branch:* Petroleum Fuels in Canada 1935.
*Canada, Dept. of Mines and Resources, Mines and Geology Branch:* Investigations in Ore Dressing and Metallurgy, July to December 1935.
*University of Minnesota Engineering Experiment Station, Bulletin No. 12:* Thermal Conductivity of Building Materials, by Frank B. Rawley and Axel B. Algran.
*University of Toronto, Faculty of App. Science and Engineering, School of Engineering, Research Bulletin No. 149:* Heat Insulation as Applied to Buildings and Structures, by E. A. Allcut and F. G. Ewens.

### Technical Books, etc.

Canadian Trade Index 1937 (*Canadian Manufacturers Association*).
The Engineering Index 1936.
Refrigeration Engineering, by H. J. Macintyre (*John Wiley and Sons, New York*) (*Renouf Publishing Company, Montreal*).
Man in a Chemical World, by A. Cressy Morrison (*American Chemical Industries Tercentenary*).
Storage Reservoirs, by George Bransby Williams (*Chapman and Hall Ltd., London*).
Lectures on Organization, by Russell Robb (*Presented to The Institute by H. A. Hopf, New York*).

# BOOK REVIEWS

## Metallic Corrosion Passivity and Protection

*By Ulick R. Evans. Edward Arnold and Company, London (Longmans, Green and Company, Toronto). 1937. 6 by 9¼ in. $13.50. Cloth. 720 pages.*

Reviewed by Harold J. Roast, M.E.I.C.*

Dr. Evans' previous work on "Metals and Metallic Corrosion" naturally leads one to expect a highly scientific and mathematical treatise in the case of the new book and the reader will not be disappointed. In the preface one finds "The present work is an attempt to summarize the existing knowledge, and is based on the investigations and writings of about seventeen hundred authors whose names appear in the index." When one finds in addition to this that the technical publications quoted number well over three hundred, it is no surprise that the book is one of over seven hundred pages.

The author is to be complimented in the idea followed throughout the book of dividing each subject into three sections (A), (B) and (C). (A) is devoted to the scientific basis, (B) discusses the practical problems and under section C is what the writer pleases to call "A very *elementary* quantitative discussion of those cases which are sufficiently simple to be represented by equations." Actually the mathematical demands made on the ordinary engineer in section (C) will be ample to brighten up his mathematical viewpoint. The book throughout is logical and one can read section (A) throughout, or (B) throughout, and get a very connected idea of the subject, depending on what viewpoint is considered the most interesting.

A comparison of ordinary steel with stainless steel on page 231 is informative and on page 234 "Internal Corrosion of Iron Pipes and Jackets" is an example of the practical way in which the various subjects are treated and in this particular instance the corrosion due to moving liquids. The same might be said of page 253 "Influence of Arsenic on Brass." The discussion on page 650 of "The Fallacy of Anodic Testing" indicates frankness and fearlessness on the part of the writer based on his intimate knowledge of the case.

In the last chapter under "Testing (C)—Quantitative Treatment Statistical Considerations" under the heading "Methods of Minimizing Errors" an interesting and informative discussion is shown.

Some headings from section (B) might indicate a general idea of the work—"Stray Currents, Attack on Metals Underground," "Plain Acid Pickling of Steel," "The Requirements of Heat-resistant Materials," "Public Fuel Policy and Corrosion," "Control of Corrosion by Additions to the Corrosive Liquid," "Materials for Chemical Industry," "Effects of Stress and Strain on Corrosion," "Protection by Metallic Coatings," "Protection by Paints and Enamels," etc.

Anyone who is called upon to give advice on prevention of metallic corrosion should not be without this latest work in this connection. After reading the book one may feel, that in view of the fine points referred to, no form of complete metal preservation is possible. It still remains, however, that the more one takes advantage of the latest scientific knowledge, the more permanent will metal protection become.

**Canadian Bronze Company Limited, Montreal.*

## Asphalt Pocket Reference

*By Prevost Hubbard and Bernard E. Gray. The Asphalt Institute, New York. 1937. 225 pages. Flexible, leather finished, vest pocket edition.*

The new and enlarged Asphalt Pocket Reference for Highway Engineers recently issued contains seventeen chapters, comprising a comprehensive handbook of all phases of asphalt highway construction. Among the chapter headings may be mentioned the following: Terms Relating to Asphalt; Paving Plants; Design of Asphalt Pavements; Condensed Construction Specifications for Asphalt Surfaces and Pavements; Non-Bituminous Bases; Maintenance and Resurfacing; Asphalt Joint Filling and Bedding Courses; Airports; and Asphalt Revetment and Jetty Construction.

Copies of this manual may be secured without charge upon request to The Asphalt Institute, 801 Second Avenue, New York, N.Y.

## JOINT MEETING OF THE INSTITUTE WITH THE AMERICAN SOCIETY OF CIVIL ENGINEERS

### Boston, October 6th, 7th and 8th, 1937

As already announced in The Journal, The Institute, at the invitation of the Board of Directors of the American Society of Civil Engineers, will participate in the Society's Fall Meeting in Boston, Mass., on Wednesday, Thursday and Friday, October 6th to 8th, 1937. The detailed programme is in preparation and will be available shortly.

At the technical session for which The Institute is responsible, the following papers will be presented and discussed:

The Substructure of the New Highway Bridge over the Fraser River at New Westminster, B.C., by W. G. Swan, M.E.I.C., consulting engineer, Vancouver, B.C.

Recent Developments at the Port of Halifax, N.S., by E. H. James, M.E.I.C., consulting engineer, Montreal.

The Conception and Design of the Outardes Hydro-Electric Project, by H. G. Acres, M.E.I.C., consulting engineer, Niagara Falls, Ont.

Announcements will be made later regarding hotel and railway arrangements. The time and place are attractive and a large contingent of Institute members is expected to head for Boston in the first week of October.

# BRANCH NEWS

## Edmonton Branch

*M. L. Gale, A.M.E.I.C., Secretary-Treasurer.*
*F. A. Brownie, Jr.E.I.C., Branch News Editor.*

THE ISLAND OF ORLEANS BRIDGE

The April 9th meeting of the Edmonton Branch, which was held in the Macdonald hotel, had the pleasure of having a paper by P. L. Pratley, M.E.I.C., on "The Island of Orleans Bridge." This paper was published in full in the Engineering Journal for July 1936.

RECENT IDEAS IN EARTHWORK ENGINEERING

The final dinner meeting of the Edmonton Branch for the 1936-1937 season was held at the Macdonald hotel on April 28th, 1937. At the short business meeting a new slate of officers was elected for the ensuing year including J. D. Baker, M.E.I.C., as Branch chairman.

Professor I. F. Morrison of the University of Alberta presented a paper dealing with "Recent Ideas in Earthwork Engineering." The paper was of particular interest due to the fact that in 1936 the speaker had attended the Harvard Conference on Soil Mechanics and Foundation Engineering, the first world conference of its kind ever held.

In pointing out the peculiar position of earth or soil in engineering, Professor Morrison stressed the fact that these materials are the commonest with which engineers have to work and yet they are probably the least well known of all engineering materials. This is because soil is a much more complex and variable substance than other engineering materials. However, recent developments in physical chemistry and increased interest in soil research have so opened up the subject that empiricism in dealing with soils is now being replaced by more rational methods.

An outline of the most important developments to date in the science of soil mechanics was followed by a discussion by the speaker of the fundamental concepts necessary for an understanding of the subject.

Soil being defined as an aggregate of particles, the characteristics of these particles—size, crystalline character, shape and grading—are of great importance. Perhaps more important still however than those fairly obvious qualities is the fact that each soil particle consists not only of the particle proper but of a film of adsorbed water so thin that it behaves quite differently from free water.

Next speaking of the aggregate, Professor Morrison explained its most important properties: cohesion, interparticle friction, interlocking and the density state, "cohesion" between particles arises from molecular attraction and the action of water and colloidal matter surrounding the particles. Particle interlocking along with other qualities governs the ability of a soil to resist shear, or in short, its stability. The importance of this stability in engineering is obvious and the possibility of its being anticipated, through control of soil water especially, offers great possibilities particularly in road building.

Density state in any soil refers to its condition as between a maximum of void space. This quality too is of great importance since for foundation purposes a dense soil should not be deformed while a loose soil may require compaction or other treatment.

The meeting voted its hearty appreciation of the paper and a brief discussion followed in which Professor Morrison answered questions. Branch chairman E. Stansfield, M.E.I.C., presided.

## Hamilton Branch

*A. R. Hannaford, A.M.E.I.C., Secretary-Treasurer.*
*W. W. Preston, S.E.I.C., Branch News Editor.*

AUTOS AND GASOLINES

A popular subject discussed by an authority—that is what attracted an audience of 120, including several ladies, to a meeting of the Hamilton Branch E.I.C. held in McMaster University on May 4th, 1937. The title of the lecture was "Motor Car Engines and Their Fuels," and the speaker, introduced by the chairman, Col. E. G. MacKay, A.M.E.I.C., was Mr. P. B. MacEwen, combustion engineer of the Ethyl Gasoline Corporation. Mr. MacEwen illustrated his lecture with a talkie and slides, and also demonstrated the effect of different fuels on a testing engine which was equipped with a quartz window in the cylinder head, a thermo couple in the combustion chamber and meters to measure h.p., r.p.m., and temperature.

At first engineers thought that the knock in an auto engine was caused by some mechanical defect, but when mechanical improvements offered no solution, they turned their attention to the fuel being used. They decided to see what happened inside the combustion chamber of an engine, and inserted a quartz window in the cylinder head. It was found that under normal conditions the gas exploded with a blue flame, and that under knocking conditions the flame was white. Motion pictures of these explosions have revealed that when the flame is blue the explosion wave leaps across the combustion chamber from the spark plug to the opposite cylinder wall, but with a white flame there are two waves; one wave, ignited by the spark plug, and also a wave that shoots back from the far cylinder wall which is so hot that it sets off a counter explosion. When these two waves collide the engine knocks.

Realizing that excessive heating of the cylinder walls promoted knocking, research engineers sought a fuel which would produce less heat. The speaker demonstrated that gasoline containing ethyl fluid satisfied this condition. Ethyl fluid contains tetraethyl lead, ethylenedibromide, ethylenedichloride and a dye for indication.

The relationship of an automobile engine to its fuel was then discussed. Every gasoline must be blended to give an engine its best performance at all times. For starting, a light gasoline is required; for acceleration, a heavier grade; and for power, a still heavier gasoline. A proper mixture of these component assures the motorist of efficiency. The reason that one does not get more miles to the gallon of gasoline is partially due to the fact that 70 per cent of its potential power is lost to the cooling water and the exhaust. These losses may be decreased by increasing the compression ratio, but as the compression ratio rises there is more likelihood of knocking. Speed of operation has a marked effect on gasoline consumption. Most miles per gallon are obtained at 20 m.p.h., and consumption is doubled at 70 m.p.h. The position of the spark is of utmost importance. There is no advantage in using a better fuel, stated Mr. MacEwen, if the spark is not advanced to permit the motorist to take advantage of the extra power available. Another consideration concerns the valves. As about 60 per cent of the cooling of the valve is through the valve-head, the valve should rest on its seat as long as possible to lower its temperature and lessen the tendency to knocking.

Following the discussion at the conclusion of the lecture, P. Ford-Smith, M.E.I.C., proposed a vote of thanks to the speaker, and the meeting adjourned for refreshments.

## Lethbridge Branch

*E. A. Lawrence, S.E.I.C., Secretary-Treasurer.*
*R. F. P. Bowman, A.M.E.I.C., Branch News Editor.*

On Saturday evening, March 13th, 1937, the Lethbridge Branch held a joint dinner meeting with the Association of Professional Engineers of Alberta and the Rocky Mountain Branch of the Canadian Institute of Mining and Metallurgy. During the dinner music was provided by George Brown's instrumental quartette following which community singing was indulged in. Monologues by A. J. Branch, A.M.E.I.C., 'cello solos by Mr. Gordon Hendersen and vocal solos by Mr. T. Smith were also received with applause.

The Branch's new chairman, J. M. Campbell, A.M.E.I.C., presided over the meeting and called on N. H. Bradley, A.M.E.I.C., to introduce the speaker of the evening, A. W. Haddow, A.M.E.I.C., President of the Professional Engineers of Alberta, who addressed the meeting on "Some Early Examples of Engineering."

Mr. Haddow advanced the theory that the landmarks of civilization are of an engineering nature and developed this theme, by examples from earliest times. The first mile post in the development of man lay in his aquiring control over fire. The development of the bow and arrow which made him more superior in defense and the acquisition of food came next. The use of burnt clay vessels marked another forward step, leading to the storing of water and the boiling of foods and with this stage attained man could be said to have passed from the savage to the barbaric state. In this latter state the development of metals is a predominating characteristie and with the invention of writing it may be said that civilization is attained. The last and most recent stage has been the substituting of mechanical power for man power. Mr. Haddow illustrated the growth of civilization by describing the early civilizations of the Tigris, Euphrates and Nile rivers, where at very early times the construction of canals and dykes was practised with a view to irrigation and flood control. The buildings of Babylon were great feats of engineering achievement, while in Egypt, the erection of gigantic temples and monuments illustrates the great capabilities of the early engineers. Among the Egyptians we also find the early beginnings of marine engineering, together with the use of trusses for stiffening the hulls of ships.

Recently another civilization has been brought to light in Crete where much evidence of engineering development has been found, particularly in the use of terra cotta pipe and stone sewers with arched roofs.

The Greeks, Mr. Haddow said, were too interested in speculation to pay much attention to the concrete problems of engineering but their successors, the Romans, have left us many samples of their engineering genius of which we all know.

At the conclusion of his address Mr. Haddow showed a number of slides of Egyptian engineering works, the projector being operated by Mr. Cyril Watson. J. Haimes, A.M.E.I.C., moved a vote of thanks to Mr. Haddow which was heartily endorsed by those present.

## London Branch

*D. S. Scrymgeour, A.M.E.I.C., Secretary-Treasurer.*
*Jno. R. Rostron, A.M.E.I.C., Branch News Editor.*

The regular monthly meeting of the Branch was held on April 22nd, 1937, in the Public Utilities Commission's Board Room. The speaker of the evening was Mr. R. S. Charles, B.Sc., who gave a travelogue of his experiences while searching for public water supplies in France, Indo-China and Algeria.

The chairman of the Branch, A. O. Wolff, M.E.I.C., presided.

After the reading of the minutes, which were unanimously adopted, E. V. Buchanan, M.E.I.C., introduced the speaker, who in his introductory remarks referred to Professor Reavely's address to the Branch at the February meeting. He discussed the professor's description of ground water and its relation to geology.

The writer very much regrets that owing to a misunderstanding of the date of this meeting he was not present and is therefore unable to give a proper account of the speaker's address.

From outside sources however he learns that in all the countries named a thorough description was given covering the geological formation, the rotary drilling operations, the construction of wells, the quality and quantity of the waters found, climate, water divination, method of financing and labour troubles.

The latter part of the speaker's talk was devoted to a very complete description of the conditions, geological and otherwise, in southern Ontario—also covering methods of finding water, test holes, contamination of water from deep drillings, leaks, methods of modern well construction, large diameter rotary drilling, concreting outer casings, under reaming, etc.

A very animated discussion followed, various members particularly interested in water supplies voicing their experience and opinions.

A vote of thanks was moved by W. C. Miller, M.E.I.C., seconded by W. G. Ure, A.M.E.I.C., and unanimously carried.

Twenty-two members and guests were present.

## Niagara Peninsula Branch

*P. A. Dewey, A.M.E.I.C., Secretary-Treasurer.*
*C. G. Moon, A.M.E.I.C., Branch News Editor.*

An electoral meeting held at the Ontario Paper Company, on May 11th, 1937, reported the result of the ballot and adjourned until May 18th, when the new officials were elected and the results announced.

### Annual Meeting

The annual meeting was held on May 18th at the Leonard hotel in St. Catharines. Some sixty members and friends were in attendance. Paul Buss acted as the Reception Committee perfectly.

Chairman George H. Wood, A.M.E.I.C., presided at the earlier part of the meeting but was called away upon urgent business and handed the reins over to L. C. McMurtry, A.M.E.I.C.

After dinner, past-president Alex. J. Grant, M.E.I.C., said a few words in appreciation of the apparent health and activity of the Branch. He had expected a slump in the affairs following completion of the Ship Canal but was pleasantly surprised at so much interest being taken by the old, as well as the new members. The local industries were evidently doing their part in keeping the Branch very much alive.

A short period of entertainment was then provided, consisting of songs and tap dancing, with Mr. Clarence Colton at the piano.

Dr R. W. Boyle, M.E.I.C., Director of Physics and Electrical Engineering Division of the National Research Council, at Ottawa, was the guest speaker. C. G. Cline, A.M.E.I.C., introduced him as being well known to the Branch and remembered from February 26th, 1931, when his subject was "The Engineer in the Nation."

This year Dr Boyle chose "Technology and Peace and War," thus as usual, giving, his audience a very definite message and leading them towards thoughtful consideration of present day problems.

### Technology and Peace and War

The world is in such an uncertain state to-day, said Dr. Boyle, that people hardly know which way to turn or what is in store for them. The hydra-headed monster of doubt, ignorance and fear rules too extensively.

The gifts which the engineer and scientist have showered upon us are, in the first place, not impartially divided and, in the second place, are often used for the destruction rather than the well being of mankind.

Some are inclined to think that the scientist is to blame for this state of affairs; that he has advanced too fast and too far beyond the moral and political adaptibility of the race; that nations are prostituting his art in the interests of war rather than of peace.

Winston Churchill has said that "Man has not yet learned to conduct his own affairs for his own advantage." Perhaps there is great truth in this aspersion. The scientific mind is necessarily wrapped up and submerged in its own particular field, generally content to trust others in the application of any discovery, taking too little interest in the ultimate result.

There are many pseudo-scientists and charlatans who are quick to take advantage of the devices and principles of science for their own selfish ends or to promote political gain. An example of this is the doctrine of Aryanism and the form of Hitlerism preached in Germany to-day.

Without doubt the pace of living has accelerated, The strain of keeping up with the procession is great. There is little time for rest and meditation, the results are showing in an increase of mental and nervous disorders, disorderly thinking being but one of the symptoms.

While there appears to be little but toil and turmoil in the world to-day, yet there are possibilities of hope. History teaches that many an important discovery has been born in such trying times, undreamed of by those who will be most affected. Napoleon had shaken Europe and the Congress of Vienna was occupying men's thoughts at the same time that modern spectroscopy and Rumford's and Carnot's theories of heat were crystallizing. Which of these had the greatest effect upon the world and human relations?

Mankind is an adjustable animal and, given time, can adapt himself to changed conditions. The adjusting period, however, is always a time of stress. New inventions may create unemployment temporarily, but they lead to other means of occupation and, properly directed, to a higher standard of living and a fuller life.

The crux of the matter is direction, leadership. You may place the blame for our social backwardness where you will, on teachers, politicians, businessmen, clergymen, or scientists as citizens but don't blame science. And don't forget to place the blame where it properly belongs, viz., on yourselves.

Thunder clouds of war hang over the world. Thunder clouds, produced not because there is the "will" to war, but because no one seems to have solved completely the problem of using science and the products of science in such a way that mankind will be benefited and not harmed therefrom, and great sections of the people given employment to keep them from starving in the midst of plenty.

As Julian Huxley says, the realistic but deplorable attitude about war seems to be this—as long as there is a real risk of war, the fullest resources of science should be used (1) to make war militarily as efficient as possible at the least possible cost; (2) make it as merciful as possible (binding up the wounded, curing the sick and easing the dying); (3) make it as unlikely as possible by rapid and varied means of international communication, interchange of personalities and ideas in the spheres of politics, literature, language, art, music and science. But if we will have war we can be quite assured of three things: (1) we cannot have it consciously gentle, it will be mechanical and remorseless with the release of animal passion; and as time advances an increasing proportion of the nation will get killed or become sick and hurt; (2) we cannot have it cheap; (3) its dislocations economically and in society will be deeper and more disruptive than ever before. It is incorrect that there is no better method than to cry "war" and in our search for work create employment only in the manufacture of war materials.

A "Science of Peace" is greatly to be desired. This precious term we should seek to popularize. This science would carry within it the essence of truth and not be mere guesswork by diverse groups who perforce see but their own side of the picture. Society must learn to use, or to make use of, the scientist and direct his trained mind to this purpose. Then will we find a solution for this problem.

A scientific peace and employment clinic—The country which first takes the necessary steps to provide such a clinic of minds trained to search for social truth will confer a boon upon all mankind.

## Ottawa Branch

### Light Waves in Gauge Standardization

At the noon luncheon at the Chateau Laurier on April 22nd, 1937, R. H. Field, A.M.E.I.C., of the staff of the National Research Laboratories, gave an address on the use of light waves in gauge standardization.

Some gauges nowadays, stated Mr. Field, are sold commercially with an accuracy as high as two one-millionths part of an inch; and his address dealt with methods employed at the Laboratory for verifying or standardizing such gauges. In comparing present-day results with those of the days of James Watt, who succeeded in boring the cylinders of his engines to within three-sixteenths inch error from the true cylindrical form, the speaker brought out two points: first, the remarkable advance attained in the precision of machined products; and second, that the necessity for making measurements in the standards laboratory to a one-millionth part of an inch or less is dictated by the needs of hard-headed engineers.

Today, practically all precision machine-shop work is controlled primarily by Johansson gauges. These were first introduced in Sweden in 1910 after many years of development work on the part of their inventor. They are simple in form—rectangular blocks with two opposite faces determining the dimension. These faces are very accurately finished as to distance apart, parallelism and planeness. In fact the finish is really an optical polish. Such surfaces have the valuable property of adhering together when properly wrung. Hence, by wringing two or more gauges together a new gauge is formed, of length equal to the sum of the components. In this way the usual complete set of 81 blocks can be made to form a series of gauges from 0.2 to 10 in. in steps of one ten-thousandth of an inch.

The older micrometric systems of calibration for such gauges in terms of the legal standard are either insufficiently accurate, or their execution too laborious. In nearly every case, nowadays, they are primarily standardized by means of light waves.

The major portion of Mr. Field's address was taken up with a description of the procedure required to effect this standardization by such means.

## Sault Ste. Marie Branch

*N. C. Cowie, Jr.E.I.C., Secretary-Treasurer.*

A general meeting of the Sault Ste Marie Branch of The Engineering Institute of Canada was held in the Windsor hotel, Sault Ste. Marie, on March 19th, 1937.

After a short business meeting the chairman, C. W. Holman, A.M.E.I.C., introduced the speaker, Mr. H. R. Hipwell. Mr. Hipwell, the instructor of machine shop practice at the Sault Ste. Marie Technical and Commercial High School, presented a very interesting paper entitled "The Teaching of Machine Shop Practice."

Mr. Hipwell emphasized that the primary purpose of any school was the development of character and right thinking, and that a community cannot be greater than its citizens. Secondly, they aim to impart knowledge and to teach skill. After outlining the functions of the departments of the Technical School and the academic background given to each course, he gave details of the work covered in a three year course of machine shop practice. He then compared this course with that of the industrial apprentice from the standpoints of shop hours and subject matter. A description was given of the equipment and the details of the different operations which are taught both on the machines and as bench work and the need for co-ordination between the different departments to develop a better insight into the work. The importance of teaching safety measures was mentioned.

The paper was illustrated with shop blue prints and large scale charts, samples of the work done by the students were shown. One of the charts based on a survey in Milwaukee showed that 78 per cent of the apprentices from the Technical School stayed in the industry, whereas but 22.8 per cent of those from all other sources remained in the industry after one year.

The speaker closed his remarks by stating that the records of the students were available to those seeking employees.

Mr. Hipwell was sincerely thanked for his interesting paper by the members and guests present at the meeting.

The Sault Ste. Marie Branch of The Engineering Institute of Canada held a general meeting at the Windsor hotel on Monday, April 26th, 1937.

Fifteen members and guests were present to enjoy the dinner served in the hotel grill room at 6.45 p.m.

Following the dinner a short business meeting was held at which a few routine matters were speedily dealt with.

The chairman, C. W. Holman, A.M.E.I.C., then called the general meeting to order and asked W. A. Dawson, A.M.E.I.C., the chairman of the Papers Committee, to introduce the speaker of the evening.

A very interesting illustrated paper entitled "The Maintenance of Worn Parts by the Oxy-acetylene Process" was then given by Mr. R. J. Anderson of the Dominion Oxygen Co., Montreal.

Mr. Anderson first mentioned the economic factors that should be considered in any application of surfacing for wear, the choice of the surfacing material and typical materials for surfacing operations. With the aid of a number of slides the speaker then outlined many ways in which machine parts were being maintained by this method.

Mr. Anderson was thanked for his interesting paper by the meeting on a motion of J. L. Lang, M.E.I.C., seconded by O. A. Evans, Jr.E.I.C.

## Toronto Branch

*J. J. Spence, A.M.E.I.C., Secretary-Treasurer.*
*D. D. Whitson, A.M.E.I.C., Branch News Editor.*

The regular meeting of the Toronto Branch of The Institute was held at Hart House, with Otto Holden, A.M.E.I.C., Branch chairman, presiding. The speaker, Mr. McKenzie Williams, B.A.Sc., of the class of 1910, Faculty of Applied Science, University of Toronto, delivered a very interesting address on "Some Vital Economic Developments in Relation to Engineering," illustrated with a large number of very carefully prepared graphs and charts. Mr. Williams was for many years with the well known firm, A. E. Ames and Company, and at present is the director of investments and research for Corporate Investors Limited, and from his wide experience he treated those fortunate enough to be present with a store of information that should prove valuable to them to say the least.

The speaker opened his address by commenting on the general lack of information in the inter-relation of all business, and stated that from such records as were available that all the indices indicate that the recent depression in business is definitely over, and that despite our present feelings on the matter, the recent depression was not the worst, for in 1837 all the banks throughout Canada and the United States closed their doors. Cycles of business did not always exist, said the speaker, and at one time, plagues, wars and acts of God were the only upsettors of business activity. It was only when physical power and money power became linked to extend credit to producer, manufacturer and purchaser, that business cycles were born.

The basis of business forecasts, reliable enough to guide a business man's actions, can only be obtained by the accumulation of factual material related to trade, similar to actuarial or insurance knowledge, and then only a proper interpretation will yield a successful conclusion. Building statistics, car loadings, bank clearings are all barometers of business and may be misleading due to unknown quantities of freight and express carried by trucks and airplanes, car loadings no longer indicate business activity the way they did in previous years. Other indices that must be watched are the physical volume of business, the national electric power production, the mineral production, the turnover of bank deposits, bank debits, and the rise and fall of interest rates on loans to finance business and manufacturing. The speaker thought that one of the surest indicators of the future trends in business was the relation of the short term loan interest rate to the long term loan rate. Whenever the short term rate rose near the long term rate it was a sure indicator of an approaching recession in business. Several months before the memorable crash in 1929 the short term rate actually rose above the long term rate, and the same relationship has held good previous to earlier depressions.

The speaker thought bond prices were also a worth while indicator of the state of business, and the best way to conserve capital during a period of insecurity is to purchase high grade short term bonds. Senior gold stocks always decline in value during a period when commodity prices are rising. The most stable securities are those of sound companies in the field of consumers goods, and the most variable are those of companies producing the so-called durable goods and the instruments of production. During a period of rising prices, when a business cycle is emerging from a low point and starting on the way up, one is in a position to increase his capital by buying stocks of sound companies engaged in the production of commodities such as copper, nickel, lead, zinc, rubber, etc., and companies manufacturing "goods" that will become new capital investments such as steel and cement or other products that will enter into the creation of buildings, power plants, railroad equipment, generators and other forms of "capital" because such creations will be needed in the upswing of the next business cycle.

The speaker showed graphs to illustrate that increases in the amounts of gold produced were always the forerunners of an extended rise in commodity prices and that based on the huge increases of gold in the last two years, he predicted a long period of rising prices and increased business ahead. This was certainly good news for engineers in particular, and all present agreed that Mr. Williams' talk was extraordinarily instructive and the Branch would be fortunate indeed if it could secure his services again in the not too distant future.

### Annual Meeting

The annual meeting of the Toronto Branch of The Institute was held on Thursday, April 1st, 1937, at the quarters of the Canadian Military Institute on University Avenue. A large and enthusiastic turnout enjoyed the dinner which preceded the annual meeting, and the Branch was privileged to have as guests R. L. Dobbin, M.E.I.C., of Peterborough, vice-president of The Institute, E. P. Muntz, M.E.I.C., Councillor of the Hamilton Branch, and W. T. Fanjoy, A.M.E.I.C., Secretary of the Peterborough Branch, and Colonel E. G. MacKay, A.M.E.I.C., chairman of the Hamilton Branch. Brigadier General C. H. Mitchell, M.E.I.C., and Dr. F. A. Gaby, M.E.I.C., past-presidents of The Institute, were also present.

Following the dinner the guests were welcomed by Otto Holden, A.M.E.I.C. the Branch chairman, and the business of the annual meeting was commenced.

The chairman reviewed the various activities of the Branch during the past year and referred to the more important matters, including: the work done in the study of various proposals for Consolidation; the request of the Branch Executive to Headquarters to have a study made for presentation to students thinking of entering engineering, of the supply and demand for engineers; a resolution recommending the reduction in size of the Council of The Institute; local arrangements for assisting in the celebration of the Semicentennial of The Institute; a joint luncheon being arranged in honour of Professor R. W. Angus, M.E.I.C. by various engineering societies in Toronto.

The following reports were submitted to the Branch and adopted: (*a*) The Secretary-Treasurer's report by W. S. Wilson, M.E.I.C., showing a small surplus for the year; (*b*) The report of the Membership Committee by W. E. P. Duncan, M.E.I.C.; (*c*) The report of the Committee on Student Relations, by A. M. Reid, A.M.E.I.C.; (*d*) The report of the Publicity Committee by A. U. Sanderson, A.M.E.I.C., stressing a gratifying increase of space in the local press concerning our activities.

J. R. Montague, A.M.E.I.C., and E. A. Cross, M.E.I.C., were appointed and kindly consented to act as auditors and later reported that they had examined the books, pass books, and vouchers pertaining to the Branch and found them correct.

A discussion was then held on the report of the Committee on Consolidation and on the ballot on Consolidation to be returned to Headquarters April 20th, 1937. Mr. Holden read a statement from A. B. Crealock, M.E.I.C., outlining the various steps leading up to the presentation of the final report of the Committee on Consolidation and Council's action thereon. Mr. Holden then outlined the various actions taken by the Branch Executive on the question of Consolidation. Following this, a general discussion developed on various points and on the ballot and was participated in by many of those present including the guests.

The scrutineers then reported the results of the election of officers for 1937-1938.

The incoming chairman, A. U. Sanderson, A.M.E.I.C., then took the chair and spoke briefly.

LOOKING BHCKWARD AND FORWARD

On April 13th, 1937, at the Royal York hotel, Toronto, the Toronto Branch of The Institute had the pleasure of participating with four other local branches of engineering societies in a luncheon held in honour of Professor R. W. Angus, M.E.I.C., head of the department of mechanical engineering, Faculty of Applied Science, University of Toronto.

A large and appreciative audience heard Professor Angus speak on the subject "Looking Backward and Forward—Fifty Years of Engineering."

The societies participating were the American Society of Mechanical Engineers, American Institute of Electrical Engineers, the Institute of Radio Engineers, the Ontario Chapter of the American Society of Heating and Ventilating Engineers and the Toronto Branch of The Engineering Institute of Canada.

Otto Holden, A.M.E.I.C., immediate past-chairman of the Toronto Branch of The Institute, occupied the chair during the gathering.

## Vancouver Branch

*T. V. Berry, A.M.E.I.C., Secretary-Treasurer.*
*J. B. Barclay, A.M.E.I.C., Branch News Editor.*

At a dinner meeting of the Branch on May 4th, 1937, Mr. W. J. Johnson, who is attached to the engineering staff of the British Columbia Insurance Underwriters Association, gave an address on "Automatic Sprinkler Equipment."

Mr. Johnson gave a brief historical sketch of the development of the sprinkler from its humble beginning in the last century, which was just a perforated pipe turned on by hand. In 1861 the first automatic head was used and has improved till we have the type of head used today.

The automatic sprinkler has been the means of saving billions of dollars. Of 60,000 fires where sprinklers were used, 97 per cent have been arrested or put completely under control, in many cases the fires having been put out before the arrival of the fire department. Of the remaining three per cent which were a total loss it was found that one per cent alone was due to the water being turned off and the balance to causes other than the sprinkler equipment.

It has been found that sprinkler heads go wrong only once in 50,000 cases, and the Underwriters laboratories are continually testing new heads, new types of equipment and are always ready to help the engineering profession in installing sprinkler equipment.

Two systems are in general use today. The wet system, which has water in the pipes all the time, and the dry pipe system which has to discharge the air in the pipes before water can take its place. The former is the quicker acting but it is necessary to use the latter where there is danger of freezing in the pipes.

Considerable reduction of insurance rates is allowed in a building, properly designed to reduce fire hazards, and where properly designed sprinkler equipment is used. It is necessary to take care of such details as: sufficient water must be available; enough heads are to be used; feed pipes must be of proper sizes; equipment used must be passed by the Fire Underwriters Association; maintenance of equipment must be kept up.

At the conclusion of the address a vote of thanks was proposed which was heartily endorsed by the members who had enjoyed a most interesting and instructive paper.

## Winnipeg Branch

*H. L. Briggs, A.M.E.I.C., Secretary-Treasurer.*

At the meeting of the Winnipeg Branch of The Institute held on April 15th, 1937, an interim report by J. T. Rose, A.M.E.I.C., chairman of the Research and Investigation Committee of the Branch, announced the appointment of Professor A. E. Macdonald, M.E.I.C., as chairman of a subcommittee to study a matter of importance now before the public eye in that city, namely "Foundation Conditions of Small and Medium Sized Buildings." Mr. Rose also announced the appointment of T. C. Main, A.M.E.I.C., as chairman of a second subcommittee to study the related subject of "Ground Water Conditions in Winnipeg."

Mr. C. S. Landon, Registrar of the Association of Professional Engineers of Manitoba, delivered the paper of the evening on the subject "History of the Association of Professional Engineers of Manitoba." The act incorporating the Association was given Royal assent on March 27th, 1920, the initial registration being one hundred and sixty-eight engineers. In 1935 the act was repealed and a new one substituted, such as gave Council more discretion in their actions. Since formation, the Association has had to go to court only once, and then with favourable results. Mr. Landon said that whatever the result of the present ballot on consolidation, nothing should be allowed to disturb the present very cordial relations between the Association and the local Branch.

After considerable discussion, a hearty vote of thanks to the speaker was moved by Professor G. H. Herriot, M.E.I.C.

A SPECIAL GENERAL MEETING

A special general meeting of the Branch was held on May 20th, 1937, the occasion of the visit of the President of The Institute.

Mr. Desbarats presented the membership with the results of the recent ballot on the consolidation amendments after paying tribute to the enormous amount of work performed by Mr. Pitts, his committee, and others working on the problem. However, the ballot of the membership was unfavourable, and his purpose in coming to Winnipeg was to get a cross section of the opinion of Manitoba engineers as to their stand in the matter, Manitoba having presented a definite consolidation proposal to Council some two years ago.

After his brief address, the meeting was opened for the presentation of views of members, which continued at some length, until the meeting adjourned for coffee and biscuits. The sincere thanks of the Branch to President Desbarats for his visit was expressed by F. G. Goodspeed, M.E.I.C., and endorsed unanimously.

To honour J. G. Sullivan, LL.D., M.E.I.C., upon the occasion of the conferring upon him by the University of Manitoba of the honorary degree of Doctor of Laws, the Winnipeg Branch joined with the Association of Professional Engineers of Manitoba on May 27th, in a well attended dinner at the Royal Alexandra hotel. In attendance were His Honour the Lieutenant-Governor of the Province of Manitoba, and distinguished members of the engineering and sister professions. E. V. Caton, M.E.I.C., and President of the A.P.E.M., acted as chairman of the evening.

Dr. Sullivan is the most recent recipient of the Sir John Kennedy medal.

## Earthquakes and Buildings

A considerable amount of reliable data relating to distant earthquakes has been accumulated and analysed during the past half century, but this is only of secondary value to civil engineers, since there are good grounds to support the view that only near earthquakes cause extensive damage to buildings and structures in general. One important obstacle to progress in earthquake study hitherto has been the want of suitable instruments for recording the intensities of near shocks, and even with our present resources it is by no means easy to construct sensitive apparatus for the purpose. Engineers and architects in many countries will therefore welcome the detailed description of the apparatus mentioned in the report entitled *Earthquake Investigations in California*, 1934-1935, which has been recently issued by the Department of Commerce in the United States of America. In more senses than one the subject dealt with has applications in countries extending from China to Peru, and this goes to enhance the value of an account of the work done by a number of engineers and scientists, under the general direction of Captain N. H. Heck, Chief of the Division of Terrestrial Magnetism and Seismology in the U.S. Coast and Geodetic Survey. The measure of success achieved in work of this magnitude depends mainly on efficient organization, so that it is a matter of congratulation to note that in the year 1932 more than 3,000 completed questionnaires were received from postmasters and employees in both public and private concerns situated in various parts of California, giving information on the intensities of the disturbances felt during the year. While other parts of the country have experienced more severe shocks, California was chosen as the starting point of the survey because the characteristics of the predominant earthquakes offered an immediate return on the funds granted by Congress, though the investigations will, doubtless, be extended so as to cover all the States affected in this way. That the statistical examination of the resulting data should prove to be of the greatest value to all interested in the subject is demonstrated by the fact that the information available, even in the initial stages of the present work, was utilized in the process of designing large undertakings such as the Boulder Dam, and the Madden Dam at Panama.—*Engineering.*

## New Flow Meter Catalogue

A new 40-page catalogue on Bristol's electrical and mechanical flow meters is available for distribution by The Bristol Company of Canada, Ltd. These instruments are for recording, integrating, controlling, and indicating the flow of steam, liquids or gases.

Details are given regarding the new electric flow meter and its operation, using Bristol's Metameter principle of telemetering. Also, complete information is included on Bristol's mechanical flow meters. The publication contains useful engineering data for reference.

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*Reynold-Coventry Limited* have moved their Toronto office and warehouse from 64 Lombard Street to larger premises at 172 King Street East. Telephone unchanged, Elgin 4795.

*R and M Bearings Canada Limited* have moved their Toronto office and warehouse from 64 Lombard Street to larger premises at 172 King Street East. Telephone unchanged, Elgin 4795.

# Preliminary Notice

## of Applications for Admission and for Transfer

June 28th, 1937

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

The Council will consider the applications herein described in August, 1937.

R. J. DURLEY, Secretary.

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•The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years inthe case of a candid ate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of,age, and shall have been engaged in some branch of engineering for at least six years which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch ofengineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more year.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard.

**A Student** beshallat least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

**The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.**

### FOR ADMISSION

ADAMS—JOHN DEWITT, of London, Ont., Born at Macleod, Alta., July 26tn, 1908; Educ., B.Sc., Univ. of Alta., 1930; Summers: 1925, with the Lethbridge Northern Irrigation; 1926-27, rodman, Reclam. Service, Dept. of the Interior; 1928-29, rodman, Dept. Public Works, Alta.; 1930-32, instr'man., Dept. Public Works, Highways Branch, Alberta; with the Dept. of Highways of Ontario as follows: 1934, tiling inspr., 1935, gravel checker, 1936, grading inspr., 1937, dftsman.

References: A. A. Smith, V. A. McKillop, H. A. Brazier, W. E. Cornish, H. J. MacLeod, R. S. L. Wilson, C. A. Robb, M. L. Gale.

BORBEY, JOHN PIERRE, of 4443 Old Orchard Ave., Montreal, Que., Born at Toronto, Ont., Aug. 6th, 1910; Educ., B.A.Sc., Univ. of Toronto, 1934; 1934-35, survey work, Dept. Northern Development of Ontario; 1936 to date, designer, plate and boiler dept., Dominion Bridge Co. Ltd., Montreal.

References: F. P. Shearwood, F. Newell, R. S. Eadie, A. S. Wall, C. R. Young.

BYERS—WILLIAM CARYL, of Kenora, Ont., Born at Rouleau, Sask., Sept. 1st, 1912; Educ., B.Sc. (E.E.), 1934, B.Sc. (C.E.), 1935, Univ. of Man.; 1935 (May-Sept.), dftsman., highway plans, profiles, bridge plans, etc.; Sept. 1935 to Aug. 1936, instr'man., highway location and constrn.; Oct. 1936, inspr., subway constrn., Winnipeg; Feb. 1937, instr'man., survey of creek and soundings; Mar. 1937, engr.-inspr., i/c river bank protection work constrn., and at present temporarily employed with the Dept. of Public Works at Kenora, Ont.

References: J. N. Finlayson, E. A. Kelly, P. E. Doncaster, E. P. Fetherstonhaugh, G. H. Burbidge.

CONNOR—GERALD RUSSELL, of Kapuskasing, Ont., Born at Campbellford, Ont., July 6th, 1903; Educ., B.A.Sc., Univ. of Toronto, 1928; 1922 (4 mos),. solution helper, Dome Mines Co.; 1924 (4 mos.), inventory recorder, Bell Telephone Co.; 1925 (4 mos.), asst. chemist, Delord Smelting and Refining Co.; 1928 (8 mos.), trimbey operator, 1929-32, technical asst. to steam plant supt., and at present, instr'man., steam dept., Spruce Falls Power and Paper Co. Ltd., Kapuskasing, Ont.

References: C. W. Boast, C. R. Murdock, W. B. Hutcheson, J. R. Cockburn, F. C. Dyer, D. C. Beam, H. W. Tate, W. L. Thompson.

DUBESKY—WILLIAM, of 162 Yale Ave. W., Transcona, Man., Born at Winnipeg, Man., Dec. 15th, 1911; Educ., B.Sc. (E.E.), Univ. of Man., 1932. 1934-35, extra course in chemistry; 1928, dfting, Langley Electric Co.; 1930, surveying on steam heat extension programme, City Hydro, Winnipeg; 1931, general work, Carter Halls Aldinger Co.; 1933 to date, supt. and engr., i/c of refinery and steam plant, Radio Oil Refineries, Winnipeg.

References: H. L. Briggs, G. H. Herriot, E. P. Fetherstonhaugh, N. M. Hall, C. T. Barnes.

GEORGE—JOSEPH DAVID, of 1331 Henry St., North Battleford, Sask., Born at Urmia, Persia, March 4th, 1908; Educ., B.C.E., Univ. of Sask., 1933; 1932 (summer), survey and street constrn., City of North Battleford; 1935-37, Borden Bridge constrn., Dept. of Public Works, Canada.

References: F. G. Goodspeed, C. J. Mackenzie, R. A. Spencer, A. R. Greig, G. M. Williams.

KERRY—FRANK GEORGE, of Montreal, Que., Born at Montreal, Sept. 27th, 1911; Educ., B.Eng. (Civil), McGill Univ., 1935. Ing. E.S.S.A. (Paris), post-graduate work in welding; 1936 to date, service engr., Canadian Liquid Air Co., 1111 Beaver Hall Hill, Montreal, Que.

References: E. Brown, R. E. Jamieson, R. DeL. French, G. J. Dodd, O. O. Lefebvre.

LOVE—HERBERT W., Lieut., R.C.E., of Quebec, Que., Born at Toronto, Ont., Nov. 7th, 1913; Educ., B.Sc., Queen's Univ., 1936; 1936 (May-Aug.), works officer, under D.E.O., M.D. No. 3, Kingston, Ont.; Aug. 1936 to Mar. 1937, duty under D.E.O., M.D. No. 5, Quebec, and Apr. 1937 to date, engr. i/c of constrn., Dominion Arsenal, Valcartier, and Camp Engineer, Valcartier Military Camp.

References: W. S. Lawrence, J. E. Lyon, L. F. Grant, W. P. Wilgar, H. H. Lawson.

MANLEY—EDWARD HUGH, of Arvida, Que., Born at Thorold, Ont., May 17th, 1903; Educ., B.Sc. in Civil Engrg., Syracuse Univ., 1931; 1922-23 (summers), rodman, Welland Ship Canal; 1926 (July-Nov.), rodman, town layout, Arvida, Que.; 1926-27, material engr., Arvida; 1931-33, gen. foreman, tower excavations, Beauharnois; 1935-36, res. engr., Postal Terminal Bldg., Montreal, Duranceau & Duranceau; 1936-37, supt. of constrn. for same bldg.; at present, supt. of constrn., ore plant extension, Aluminum Co. of Canada, Arvida, Que.

References: G. M. Pitts, M. G. Saunders, C. P. Howrigan, E. R. Smallhorn.

MANN—ARTHUR DRUMMOND, Lieut., R.C.E., of Quebec, Que., Born at Toronto, Ont., Sept. 1st, 1913; Educ., (Grad. R.M.C.), B.A.Sc., Univ. of Toronto, 1932; 1929, Pilot Provisional Officer, R.C.A.F.; 1930, timekeeper, Anglin-Norcross Ltd., Toronto; 1934 to date, asst. to D.E.O., and at present works officer, M.D. No. 5, Quebec, Que.

References: E. J. C. Schmidlin, W. S. Lawrence, J. B. P. Dunbar, C. R. S. Stein, A. J. Kerry.

MORIN—JOSEPH ALBERT, of 5309 Fabre St., Montreal, Que., Born at St. Casimir, Que., Dec. 4th, 1892; Educ., I.C.S., Surveying and Mapping, and Railroad Engrg. Private tuition; 1911, chainman, Quebec and Saguenay Rly.; 1912, rodman, Can. Northern; 1912-13, topog'r., North Rly., Inst., C.P.R.; 1920-27, rodman, dftsman. and instr'man. C.N.R., mtce. of way dept.; 1927 to date, asst. engr., C.N.R., in charge of right of way surveys.

References: S. E. Oliver, R. B. Jennings, L. C. Dupuis, L. E. H. Lippe, S. J. H. Waller, J. Ferguson.

MORISSET—JOSEPH EUDORE, of Donnacona, Que., Born at Cap Sante, Que., Aug. 24th, 1897; Educ., mech. dftsman., Quebec Technical School, 1915. I.C.S.; 1915-16, mech. dftsman., Quebec Engineering Company; 1916-19, overseas, C.E.F.; 1919-20, mech. dftsman., General Electric Co., Schenectady, N.Y.; 1920-23, designing dftsman., St. Lawrence Pulp and Paper Co., Chandler; 1923-26, designing dftsman., Abitibi Pulp and Paper Co., Iroquois Falls; 1926-27, squad boss and designer, Dominion Engrg. Works, Lachine; 1927-28, asst. mill engr. and designer, Bonaventure Pulp and Paper Co., Quebec; 1928-29, Anglo-Canadian Pulp and Paper Co., Quebec; 1929-32, asst. mill engr. and designer, Price Bros. & Co. Ltd., Quebec; 1932-36, asst. to Mr. R. Savary, engr. in charge of culverts and small bridges for roads dept., Quebec Prov. Govt.; 1936-37, complete charge of design on grinder and coarse screen rooms, and all conveyors and track layout in yard, Ontario Paper Co., Thorold, Ont.; at present, asst. mill engr., Donnacona Co. Ltd., Donnacona, Que.

References: C. A. Buchanan, A. A. MacDiarmid, J. J. O'Halloran, H. J. Buncke, A. Paradis.

MUNRO—GEORGE NEIL, of 1702 Frederick St., North Battleford, Sask., Born at Deloraine, Man., Sept. 28th, 1896; Educ., B.Sc. (Civil), Univ. of Sask., 1926; 1923-24-26 (summers), rodman and instr'man., Sask. Dept. of Highways; 1926-28,

instr'man., and 1928-31, res. engr., C.N.R.; 1931-32, res. engr., Sask. Dept. of Highways; at present, inspr. on Borden Bridge, Langham, Sask., for Dept. of Public Works of Canada.
References: C. J. Mackenzie, J. J. White, A. J. Sill, A. J. Gayfer, E. K. Phillips.

McCAREY—JOSEPH NEWELL, of Temiskaming, Que., Born at Kingston, Ont., Feb. 19th, 1912; Educ., B.Sc., Queen's Univ., 1935; 1935-37, dftsman., Dominion Engineering Works, Ltd., Lachine, Que.; April 1937 to date, general pulp mill engrg., technical staff, Canadian International Paper Co., Temiskaming, Que.
References: L. T. Rutledge, L. M. Arkley, J. H. Maude.

PEACHEY—CYRIL ARTHUR, of 3417 Peel St., Montreal, Que., Born at London, England, Jan. 30th, 1903; Educ., B.A. (Maths. and Physics), Univ. of Toronto, 1927; with the Northern Electric Co. Ltd., Montreal, as follows: 1927-30, vacuum tube engr.; 1930-33, development engr. on misc. apparatus; 1933 to date, in charge of technical developments in the shop, chiefly supervising work of a group of industrial engineers.
References: G. Stead, W. H. Eastlake, J. S. Cameron, H. J. Vennes, J. D. Hathaway, J. W. Fagan.

QUINN—ODORIC CHARLES, of Riverbend, Que., Born at Montreal, July 21st, 1909; Educ., 1926-30, completed two years engrg. course, McGill Univ., withdrew from third year on account of ill health; 1927 (May-Aug.), mechanic's helper, harbour constrn., Quebec; 1929 (May-Sept.), electrician's helper, Youville Shops, Montreal; 1935 to date, engrg. secretarial work, Price Bros. & Co. Ltd., Riverbend, Que.
References: S. J. Fisher, G. F. Layne, N. F. McCaghey, A. R. Roberts, G. E. LaMothe, A. Cunningham.

RELYEA—JOHN DE WITTE, of 92 Dupont St., Toronto, Ont., Born at Cornwall, Ont., June 21st, 1895; Educ., B.A.Sc., Univ. of Toronto, 1921; 1920, asst. engr., Price Bros. & Co. Ltd., Chicoutimi; 1922-25, associate editor, Hugh C. MacLean Publications Ltd., Toronto. Usual responsibility of technical magazine editor; 1926-27, radio engrg. work and production of radio receiving apparatus and tooling for same, General Wireless and other small companies; 1928-30, asst. to plant supt., then asst. supt., mtce., production, tooling, Ward St. Works, and 1931-34, mech. supt., i/c all constrn., mtce., operations, also tooling and tool design, and all mech. and elect'l. equipment, Ward St. Works, Canadian General Electric Co. Ltd., Toronto; 1934-35, consltg. expert on investigation and improvement of factory equipment and methods and tooling in plant of Manwell's Ltd., St. Mary's, Ont.; 1935-36, gen. supt. for same company in charge all factory operations, mtce., tooling, and general betterment of plant; 1936-37, mech. engrg. design and layouts for new plant of Ford Motor Company of Canada Ltd., Walkerville, Ont.; Recently appointed to Dept. of Public Works, preparing plans and estimates of mech. equipment and heating, ventilating, power, light, telephone and signal systems, supervising constrn., installn., mtce. and repair.
References: R. E. Smythe, J. E. Tremayne, J. E. Porter, C. W. Edmonds, C. G. Walton, J. W. Ward, A. C. Blue, J. J. Traill, A. A. Smith.

RYAN—EDWARD, of 232 Sydenham St., Kingston, Ont., Born at Kingston, May 4th, 1906; Educ., B.Sc. (Civil), Queen's Univ., 1929; 1927 (May-Oct.), inspr., dftsman. and instr'man. on municipal contracts, City of Regina; 1928 (May-Oct.), inspr. and dftsman., Ontario Highway Dept.; 1929-30, instr'man., dfting., and preparing constrn. estimates, Bell Telephone Co. of Canada, Montreal; 1931-32, instr'man., dfting. and preparing constrn. estimates, and 1934 (3 mos.), foreman in charge of constrn., Ontario Highway Dept.; 1934 (Sept.-Dec.), asst. on layout of lines and levels, calculating quantities and checking materials, Fraser Brace Ltd.; 1935-36, instr'man., dfting and preparing estimates, Ontario Highway Dept.
References: W. P. Wilgar, L. E. Ennis.

SAMIS—GEORGE ROY, of 531 St. Joseph St., Lachine, Que., Born at Cannington, Ont., March 24th, 1910; Educ., B.A.Sc., Univ. of Toronto, 1932; 1928 (summer), constrn. dept., H.E.P.C. of Ont.; 1929 (summer), dftsman., Hamilton Bridge Co.; 1930 (May-Dec.), field engr., Orillia Water Light and Power Commn.; 1933 (June-Sept.), and 1934 (Apr.-Dec.), field engr., Ontario County Engineer; 1935-36, instr'man., Ontario Dept. of Northern Development; March 1937 to date, designer, plate and boiler dept., Dominion Bridge Co. Ltd., Montreal, Que.
References: C. R. Young, H. E. Brandon, R. E. Smythe, F. P. Shearwood, A. S. Wall.

SCRIVENER—RICHARD HARDING, of 116 Cluny Drive, Toronto, Ont., Born at Toronto, Ont., Feb. 1st, 1913; Educ., B.A.Sc., Univ. of Toronto, 1936; 1931-35 (summers), gen. mach. shop work; 1935 (summer), Ontario Research Foundation; 1936 to date, designer, plate and boiler dept., Dominion Bridge Co. Ltd., Montreal, Que.
References: F. P. Shearwood, F. Newell, R. S. Eadie, A. S. Wall, C. R. Young.

WEIR—WILLIAM CECIL, of Flin Flon, Man., Born at Portage la Prairie, Man., Mar. 24th, 1911; Educ., B.Eng. (Mech.), Univ. of Sask., 1936; at present, mech'l. engr., Hudson Bay Mining and Smelting Co. Ltd., Flin Flon, Man.
References: C. J. Mackenzie, A. R. Greig, I. M. Fraser, W. E. Lovell, N. M. Hall.

WESTOVER—CHANNING SPAULDING, of Pointe Claire, Que., Born at Sutton, Que., Oct. 22nd, 1885; Educ., Private study; 1907 (Apr.-Nov.), chainman, 1908 (Aug.-Dec.), and Sept. 1910 to Feb. 1911, rodman, C.P.R.; 1911-12, rodman, G.T.P. Rly.; 1912-13, instr'man., G.T.P. Rly.; 1919 (Aug.-Nov.), dftsman., Dominion Bridge Co.; Sept. 1920 to Mar. 1921 and Aug. and Sept. 1922, concrete inspr., C.N.R.; Apr. 1923, transitman, C.N.R.; 1923 (May-Nov.) transitman, C.P.R.; 1923-25, concrete inspr., Duke Price Power Co.; 1925-28, transitman, Aluminum Co. of Canada; 1928-29, instr'man., Quebec Chibougamau Rly.; 1929-30, instr'man., C.N.R.; 1930-32, instr'man., 1933, field engr., 1934, field engr., Beauharnois Construction Co.; 1934 (Sept.-Dec.), field engr., Montreal Light, Heat and Power Cons.; 1935 (Aug.-Dec.), dftsman., Dr. F. A. Gaby, M.E.I.C.; at present, instr'man., Aluminum Co. of Canada, Arvida, Que.
References: M. V. Sauer, P. G. Gauthier, C. G. Kingsmill, G. O. Vogan, E. S. Hollowell, M. G. Saunders, O. B. Bourne, P. H. Morgan.

### FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

BUNTING—WILLIAM RUSSELL, of 4550 King Edward Ave., Montreal, Que., Born at Grantham Twp., Ontario; Educ., B.A.Sc., Univ. of Toronto, 1923; 1920 (summer), elect'l. operator, H.E.P.C. transformer stn., Niagara Falls; 1921-22 (summers), electrn's helper, Queenston generating plant under constrn.; 1923-24, student engr., test course, Gen. Electric Co., Schenectady, N.Y., and Pittsfield, Mass.; 1924 to date, power apparatus specialist, Northern Electric Co. Ltd., Montreal. (*St. 1920, Jr. 1925, A.M. 1928.*)
References: F. J. Bell, J. M. Cockburn, R. N. Coke, F. L. Lawton, N. L. Morgan, N. E. D. Sheppard, K. O. Whyte, W. L. Yack.

REID—WILLIAM JOSEPH WALTER, of Hamilton, Ont., Born at Oak River, Man., Mar. 31st, 1898; Educ., B.A.Sc., Univ. of Toronto, 1924; with the Otis-Fensom Elevator Company as follows: 1921-22 (summers), factory employment; 1923 (summer), constrn. employment; 1924 (May-Dec.), student course; 1925-26, i/c of elect'l. manufacture; 1926-27, asst. constrn. mgr.; 1928-30, constrn. mgr.; 1931-33, engrg. dept., and June 1933 to date, works manager. (*St. 1920, A.M. 1929.*)
References: W. D. Black, A. Love, E. P. Muntz, C. H. Mitchell, J. J. MacKay, W. L. McFaul, H. B. Stuart, E. G. MacKay, A. R. Hannaford.

STUART—WILLIAM GREY, of Edmonton, Alta., Born at Moulmein, Burma, March 27th, 1892; Educ., Glasgow Technical College and Glasgow University; 1911-14, rodman, topog'r. and instr'man., C.P.R. constrn. dept.; 1914-19, overseas, Capt., R.F.C.; 1919-24, district hydrometric engr., irrigation br., Dept. of the Interior; 1925-32, district engr., Dominion Water Power and Reclamation Service, inspecting and laying out drainage schemes and industrial schemes; 1932-34, hydraulic engr., White Eagle Silver Mines, Camsell River, N.W.T., investigating power sites and reconnaissance; 1934, field engr., North West Minerals, investigating power sites, Tazin River; 1935, field engr., Northern Canada Development and Holdings Ltd., investigating power sites, Oldman River; 1935-36, field engr., North West Minerals, power sites, Teseljiri Falls, Tazin River; 1936-37, engr. in charge diamond drilling mine development, North West Minerals Goldfields, Saskatchewan; at present, hydraulic engr., engaged by N. A. Timmins Corporation of Montreal to investigate power sites near Fond-du-Lac, Sask. (*A.M. 1927.*)
References: J. S. Tempest, C. E. Garnett, C. J. McGavin, P. J. Jennings, O. H. Hoover.

### FOR TRANSFER FROM THE CLASS OF JUNIOR

DUNCAN—CONRAD MUNRO, of 28 Gilmour St., Ottawa, Ont., Born at Stonewall, Man., Sept. 18th, 1909; Educ., B.Sc. (C.E.), Univ. of Man., 1932; Summers 1929-32, instr'ment work and field engrg. work in connection with location, design and constrn. of roads, field work on drainage projects, Reclam. Branch, Dept. Public Works Manitoba; 1934-36, gen. field and office work on location, design and constrn. of roads, piers, trails, curbing, sewage disposal systems, etc. Prelim. surveys for electric light and water systems. Office work incl. reports, unit costs, etc. Topog'l. surveys and mapping. Instrument work on townsite subdivn. and boundary surveys, Lands, Parks & Forest Br., Dept. of Mines and Resources; June 1936 to date, compiling maps from aerial photographs and constrn. of field operation maps, Bureau of Geology and Topography, Dept. of Mines and Resources, Ottawa, Ont. (*Jr. 1936.*)
References: J. N. Finlayson, G. H. Herriot, E. W. M. James, A. E. Macdonald, E. M. Dennis, J. F. Cunningham.

### FOR TRANSFER FROM THE CLASS OF STUDENT

BURNHAM—DONALD EDMUND, of 65 Fairholt Rd. South, Hamilton, Ont., Born at Digby, N.S., Apr. 27th, 1905; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1928. Post-graduate work at McGill Univ., towards M.Eng. degree; 1928-30, student ap'tice, Canadian Westinghouse Co.; 1930-32, asst. engr., operating dept., H.E.P.C. of Ont.; 1936, dftsman., Tech. Service Bureau, Montreal; 1937, dftsman., Canadian Steel Foundries, Montreal; at present, dftsman., Canadian Westinghouse Company, Hamilton, Ont. (*St. 1928.*)
References: D. W. Callander, G. W. Arnold, R. J. Durley, C. O. Thomas, R. Ford, L. S. Cossitt, W. F. McLaren, J. R. Dunbar.

FULLERTON—ROLAND McNUTT, of Malartic, Que., Born at Halfway River, N.S., Oct. 25th, 1906; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1933; 1931 (May-Sept.), student engr., Canada Electric Co. Ltd., Amherst, N.S.; 1935-36 (4 mos.), electr'n. helper, Shawkey Gold Mines; 1936 (May-July), electr'n. on installn. of elect'l. equipment, Thompson Cadillac Gold Mines, Kewagama, Que.; July 1936 to date, electr'n. on installn. and mtce. of elect'l. equipment, Canadian Malartic Gold Mines, Malartic, Que. (*St. 1931.*)
References: G. T. Medforth, W. P. Copp, F. L. West, H. W. McKiel, G. H. Burchill.

SAINT JACQUES—JEAN, of Quebec, Que., Born at Montreal, Mar. 22nd, 1909; Educ., B.A.Sc., Ecole Polytechnique, Montreal, 1929. B.Sc. (E.E.), McGill Univ., 1931; 1926 (summer), survey work, Quebec Streams Commn.; 1927 (summer), on Isle Maligne to Dolbeau line for Price Bros. & Co. Ltd.; 1929-32, ap'ticeship course, Shawinigan Water and Power Co.; 1933-36, asst. engr., rates, rate studies, statistical analyses, power sales, supervn. of plant account, secondary power sales, and at present office engr. on similar work, for Quebec Power Company, Quebec, Que. (*St. 1931.*)
References: R. B. McDunnough, E. D. Gray-Donald, R. Dupuis, H. Cimon, A. Frigon, J. B. Challies, C. V. Christie.

VILLEMURE—J. PHILEAS, of Grand Mere, Que., Born at Ste Flore, Que., Oct. 12th, 1910; Educ., Passed E.I.C. Examinations under Schedule "A" 1931 and Schedule "B" 1937; 1929-30, dftsman., Shawinigan Chemicals; 1930 to date, dftsman., rodman, instr'man., City of Grand Mere. (*St. 1931.*)
References: E. B. Wardle, N. J. A. Vermette, W. B. Scott, O. O. Lefebvre, A. Plamondon, A. Valiquette.

## Naval Commissions for University Graduates

Of all the problems associated with a rapid expansion of naval forces in time of peace, probably the most serious is that of providing trained officers and men at a rate commensurate with the completion of the ships. The emergencies of war can be, and have been, met by recruitment on a temporary basis in conjunction with the reserves maintained for the purpose, but a peacetime expansion necessarily requires that the additional personnel shall serve as long as the ships are likely to remain in commission; and under modern conditions, a ship can be built in a third or a quarter of the time necessary to train an officer, especially a technical officer, to the point of fitness for executive responsibility. An announcement now made indicates that, in the case of engineer officers, the anticipated requirements are to be met in part by recourse to the Universities of Great Britain and Northern Ireland, by the offer to engineering graduates in September, 1937, and in each half-year thereafter, of 20 commissions as sub-lieutenant (E). It is specified that applicants must be unmarried British subjects of pure European descent, and the sons of parents who are British subjects at the time of the candidate's entry; that they must be between the ages of twenty-one and twenty-five on July 1 for appointment in the following September, or January 1 for appointment in February; and, after a course of not less than three academic years as an internal student, and a regular training and sufficient practical experience in mechanical engineering, must have obtained a mechanical or electrical engineering degree accepted by the Institution of Mechanical Engineers as exempting from Parts A and B of the examination for associate-membership of that institution. In certain circumstances, the notice adds, the first year at a recognized Dominion university may be counted towards the three years' academic training. Detailed regulations and entry forms are obtainable from the Secretary, Admiralty, London, S.W.1, or from the Universities, but the application must be made, on completion of the form, to the authorities of the candidate's university.—*Engineering.*

## EMPLOYMENT SERVICE BUREAU

The Service is operated for the benefit of members of The Engineering Institute of Canada, and for industrial and other organizations employing technically trained men—without charge to either party.

*All correspondence should be addressed to*

**The Employment Service Bureau, The Engineering Institute of Canada**
**2050 Mansfield Street, Montreal**

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INDUSTRIAL ENGINEERING EXECUTIVE, with wide experience including fourteen years in design, construction, maintenance and operation of pulp and paper mills and power developments. Now employed, desires change of location. Apply to Box No. 320-W.

STEAM AND MECHANICAL ENGINEER. Married. Wants position with industrial company within 100 mile radius of Montreal. Would prefer position in charge of maintenance. Can undertake plant layout work, handling steam lines, look after alterations or extensions, make installations on construction work. Previously in charge of similar work and can prepare own drawings. Have good all round knowledge of all trades. 35 years experience. Apply to Box No. 441-W.

DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aero-photographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.

ELECTRICAL ENGINEER, B.Sc., E.E., age 38. Married. Ten years electrical experience; including, one year operation, one year maintenance, and four years on construction of hydro-electric plants and sub-stations. Four years electric maintenance and construction in pulp and paper mill. Also experience on highway construction and Geological Survey. Available at once. Apply to Box No. 636-W.

ELECTRICAL ENGINEER, B.Sc. E.E. '28. Two years with large electrical manufacturing company including test course, about two years in supervisory operating office of a large electrical power utility, and considerable experience in electrical and mechanical draughting. Location in Ontario preferable. Apply to Box No. 660-W.

ELECTRICAL AND CIVIL ENGINEER, B.Sc. Elec. '29, B.Sc. Civil '33. Jr.E.I.C. Age 29. Experience includes four months with Can. Gen. Elec. Co., approximately three years in engineering office of large electrical manufacturing company in Montreal, the last six months of which was spent as commercial engineer. For the last year and a half employed in electrical repair shop. Best of references. Apply to Box No. 693-W.

YOUNG CIVIL ENGINEER, B.Sc. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

MECHANICAL ENGINEER, Jr.E.I.C., B.A.Sc., Univ. of B.C. '30. Single, age 30. Sixteen months with the Allis-Chalmers Mfg. Co. as student engineer. Experience includes foundry production, erection and operation of steam turbines, erection of hydraulic machinery, and testing texropes and centrifugal pumps. Location immaterial. Available at once. Apply to Box No. 735-W.

## Situations Wanted

CIVIL ENGINEER, B.Sc., M.Sc., R.P.E.; Lieut. C.E., R.O. 16 years municipal, highway and construction, 5 years overseas. Married. Read, write and talk French. Will go anywhere. Apply to Box No. 737-W.

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PLANT ENGINEER or SUPERINTENDEBT, capable of supervising all phases of industrial plant operation, graduate electrical, eleven years diversified industrial experience including test course, four years on large Quebec industrial development, on construction and operation, also six years with prominent consulting firm supervising electrical and mechanical engineering projects. Age 31, single. Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman, compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

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Members are again reminded that we are receiving an increasing number of enquiries for engineers.

If you are registered with the Employment Service Bureau please bring your record up-to-date

The more information you give us, the more intelligently and effectively we can place your record for consideration with prospective employers.

MECHANICAL ENGINEER, Jr.E.I.C., technical graduate, bilingual, age 35, married, experience includes five years with firm of consulting engineers, design of steam boiler plants, mechanical equipment of buildings, heating, ventilating, air conditioning, plumbing, writing specifications, etc. Five years with large company on sales and design of power plant, steam specialties and heating equipment. Available on short notice. Apply to Box No. 850-W.

STRUCTURAL ENGINEER, B.A.Sc., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

CIVIL ENGINEER, B.A.Sc. (Univ. of Toronto '27). Age 34. Familiar with house building cost, experience combines structural engineering, construction and house building and improvement, interested in obtaining a connection with firms investigating housing problems, making building loans or with a company engaged in construction or building costs. Apply to Box No. 910-W.

ELECTRICAL ENGINEER, B.Sc. (McGill '28), age 34. Experience includes transmission line and rural distribution construction and design. Some installation of motors and equipment, also house wiring. Available immediately. Apply to Box No. 940-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.

## Situations Wanted

ELECTRICAL ENGINEER AND GEOPHYSICIST. B.Sc. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No. 1168-W.

ELECTRICAL ENGINEER, B.Sc. '34 (Univ. of N.B.), S.E.I.C. Age 24, single. Desires any kind of electrical work. Will consider any location. Apply to Box No. 1262-W.

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CIVIL AND ELECTRICAL ENGINEER, Univ. of Man. '35 and '36. S.E.I.C. Experience in irrigation and mapping. Available at once. Location immaterial. Box No. 1418-W.

CIVIL ENGINEER, B.Sc. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

CONSTRUCTION SUPERINTENDENT, M.E.I.C. Age 49. Married. Twenty-two years experience as engineer, superintendent and manager in charge of hydro-electric, mechanical production, structural steel erection, also considerable experience in steam plants, combustion, transmission lines, millwright work, complete mine installations, rock work, rock crushers and conveyors. Executive ability. Speaking French fluently. Location immaterial. Apply to Box No. 1482-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.Sc. '31 (Univ. of Alta.), Jr.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work, location immaterial and available at once. Apply to Box No. 1522-W.

CIVIL ENGINEER, B.Sc. '32, S.E.I.C., P.E.N.B., D.L.S.N.B., age 32. Experience in mining, both coal and metals, private and legal surveys, railroad construction, geology and building construction. At present in private practice in coal mining district. Desirous of changing location for position either in mining field or construction in Canada. or abroad. Apply to Box No. 1562-W.

RESIDENT ENGINEER, familiar with all types of surveys and construction work including, railway, roads, irrigation, drainage, buildings and air ports. Executive ability. Had charge of several large projects. Intimate knowledge of reports and estimates. Available immediately. Any location. Apply to Box No. 1567-W.

CIVIL ENGINEER, B.Sc. '17, O.P.E. Married. Executive and administrative experience. Extensive office and field experience in harbour works, dredging; both steam and electric railways in location, construction and maintenance; telephone works in design, construction and maintenance of pole lines, wire, cable and conduit; highways in location, construction and paving; municipal works in roads, sidewalks, sewers and water mains. Intimate knowledge of estimating, unit costs, cost accounting and analysis. Some knowledge of air conditioning. Willing to locate anywhere. Available at once. Apply to Box No. 1587-W.

ELECTRICAL ENGINEER, B.Sc. '27 (McGill), A.M.E.I.C. Age 36. Married. Bilingual. Three years experience in telephone work (installation of manual and automatic exchanges). One year electrical prospecting. Nine years experience with electrical power company. Apply to Box No. 1601-W.

EXECUTIVE TOOL AND PRODUCTION ENGINEER, desires to make a permanent change, graduate in mechanical (Queen's '23), A.M.E.I.C., married. Well abreast with modern production methods and present competition. Competent supervisor of tool and die design and construction; operations and methods, plant layout, efficiency and time study, toll and production estimating, tooling development foundry, machine shop and designing experience. Best of references. Apply to Box No. 1653-W.

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## Contents



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# THE ENGINEERING JOURNAL

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# Air Transport in Canada

*The Hon. C. D. Howe, Hon. M.E.I.C., Minister of Transport, Ottawa.*

**An address delivered in Ottawa, on June 18th, 1937, during the Semicentennial Celebrations of The Institute.**

Visitors to Canada are somewhat surprised to find that no inter-urban air line service is available, particularly on the coast-to-coast route. From that they often infer that Canada is deficient in aviation services. The latter deduction is entirely incorrect. Canada has an aviation development which is unique in character, and of immense importance to the industrial life of the country.

Approximately three-quarters of the Dominion lies north of railway and highway transportation systems, and it is in this vast area that the use of the airplane has been of chief importance in aiding and advancing prospecting and mineral enterprise generally. Fortunately, this area has numerous lakes and waterways which provide ideal landing places for hydroplanes, so that little expenditure is required for constructing ground facilities.

Planes are equipped with pontoons while the waterways are open, and with skis for winter use. Except for a brief interval in the spring and in the autumn, when neither type of landing gear can be used, northern flying can be carried out safely, with the lakes and rivers available for summer and winter landing fields.

Canada is far in the lead of other countries in the use of the airplane in mineral development, and there are few metal mining areas of importance that are not serviced by airplanes. In the early stages of development, planes were used chiefly in the transportation of passengers, but now they are commonly used in the transportation of diamond drills, machinery of all sorts, food and other supplies, and even small milling plants. They have become indispensable to the development of areas remote from transportation.

In 1920 the first commercial use of the airplane in the far north was developed by the Imperial Oil Company, to service petroleum discoveries at Fort Norman, on the Mackenzie River. In 1922 another phase in the use of the airplane began with experiments by the Dominion Topographical Survey in aerial photography for map-making. Two years later such progress had been made that an extensive programme of aerial mapping was undertaken. In 1928 large scale prospecting by air commenced. Exploration companies equipped with their own planes made criss-cross flights over large portions of the Yukon and the Northwest Territories. In 1929 three mineral exploration companies with 24 planes reported an exploration of a total of 174,000 square miles by air. In carrying out this work, the planes flew a total of 500,000 miles, and carried 1,000,000 pounds of freight, supplies and equipment for the maintenance of prospecting parties.

In the successive stages of mineral development from prospecting to production, the airplane is used.—

1. As a means of making reconnaissance surveys.
2. For the transportation of prospectors and their equipment into promising areas.
3. Diamond drills and their crews are flown in.
4. Freighting of machinery and equipment for the new mine.
5. Gold concentrates and gold bricks are flown out.

There are in Northern Canada a number of fair-sized towns that are wholly dependant on aerial transportation for their existence. Material flown in includes mine cars, steel rails, huge boilers, cement, tractors, air compressors, etc. A team of oxen was recently flown in to one of these towns.

During recent years Canadian airplanes have carried 60 per cent of the total air-borne freight of the Empire and close to five times the total freight of all airplanes in the United States. There are eleven well-established North and south air routes in Canada at present. Edmonton's municipally-owned airport is the busiest in Canada, being the terminal for air routes into Great Bear lake, Yellowknife river, Gordon lake, Outpost Islands mining areas in the Northwest Territories, and into the Lake Athabaska area in Saskatchewan. Freight carried by all commercial aviation companies in 1936 is estimated at about 15,000 tons. It is expected that the current year will exceed that tonnage considerably.

While there has been spectacular Canadian development of transportation of freight by air, these planes also carried mail and passengers. In 1935 these planes carried 1,126,000 pounds of mail and 177,000 passengers.

The need of inter-urban air services has long been apparent, but difficulty of providing necessary landing fields has proved a serious obstacle. Prior to the depression, daily schedule services were provided from Winnipeg to Lethbridge, Calgary and Edmonton across the Canadian prairies, but during the depression years this service was suspended. These flights were made with land machines, and fairly adequate landing fields were constructed.

During the depression years the Government seriously undertook the construction of a series of landing fields across Canada from Halifax to Vancouver and between Toronto and Vancouver as an unemployment relief project. These fields were constructed with runways having a minimum length of 3,000 feet and capable of being extended to 5,000 feet and a width of 300 feet. Wherever possible, each field was provided with three runways of this dimension to permit landing under all conditions of wind and weather. All these fields were well advanced toward completion with relief labour, and all have been further advanced by contract. Today all these fields are practically completed, and it is the intention to undertake schedule flights from coast-to-coast early next year.

The magnitude of the task of providing ground services for a modern airline route across Canada will be apparent to those familiar with our geography. Northern Ontario is a wilderness of spruce forests and swamps, and to locate a field capable of being made level, to cut the trees and remove the stumps, to provide gravel for grading the runways, and to provide adequate drainage has been in itself a major engineering project.

A further and even greater engineering problem is to provide a route through the Rocky Mountains. Two mountain ranges must be crossed, and both have peaks extending far above the highest elevation possible for plane travel. Emergency landing fields must be provided at close intervals across this part of the route. The Crow's Nest Pass route has been chosen as most favourable and the necessary landing fields have been provided and brought to completion.

These fields have special problems due to our climatic conditions. The main stopping places along the route must have hard-surface runways. These are being provided where possible by impregnation of the soil with a bituminous compound; and, where the soil is not suitable for such treatment, runways of tar or asphalt are being built. For emergency fields a coating of grass is provided for summer landings. All the fields have their special snow problems. Experiments are now being carried out to determine whether the best results can be obtained by pressing down the snow with rollers, by the use of mechanical blowers for snow removal, or whether snow-plows will provide higher efficiency.

Lighting must be provided at all landing fields to mark the runways and to guide the pilot to his landing place in the event of radio failures. The main guide for the pilot is, however, a continuous radio beam, which will extend from Halifax to Vancouver. A pilot flying on this beam obtains a steady hum on his earphones. If the wind has drifted him to the north off the beam proper, the monotone disappears and he hears a dot and dash (the Morse letter "A"); while, if he drifts to the south, he hears a dash and dot (the Morse letter "N"). These provide warnings that he is off course, and directions for returning to the course. A pilot flying on his beam and equipped with the usual instruments is independent of visibility except for purposes of actually touching the ground. He requires reasonable visibility within 300 feet of the ground, but, above that, his instruments provide all required information. His landing place is located by the beacon marker situated two miles from the end of the main runway. As he follows the beam over his marker, he finds himself in a cone of silence, and from there he glides at a predetermined angle in a well-marked direction to his field. He will emerge from the clouds directly over his runway, and can land without difficulty. Those of us who have stood at a busy airfield such as Newark, New York, and have seen planes come through the clouds at intervals of fifteen minutes and take their landings without circling the field or other wasted manoeuvres, have some appreciation of the triumph of radio over adverse weather. Often the pilots who are landing have not seen the ground for hours.

While travelling on the beam, the pilot receives weather bulletins over the beam itself, and can return messages over the beam if he so desires. In addition, his plane is equipped with radio telephone, over which he can talk with any of the main or emergency landing fields along the route. Over this telephone he receives weather reports, and telephones conditions to the ground as he is finding them. Thus the pilot is well reinforced with expert advice in case of emergency.

The most important service to be provided for an airline is that of adequate weather reporting. In Canada we are rapidly expanding our weather reporting service, some 900 reporting stations now being in operation. These stations are located at strategic points from the shores of the Arctic Ocean along both sides of Hudson Bay and down to the United States boundary. In addition, we receive reports from all weather reporting stations in the United States. Reports so obtained are interpreted by highly trained analysts, who compile weather forecasts, which are sent to all landing fields every six hours by means of a teletype service connecting all the fields. Observations are not confined to the ground. Upper air observations are made by means of balloons and theremometers, so that the pilot is informed of wind speeds and temperatures for each air layer up to 10,000 feet. He receives, while in flight, instructions as to the most favourable altitude for his purpose. The efficiency of airline operation depends very largely upon the efficiency of its supporting weather service.

The route from Halifax to Vancouver has about 100 landing fields, located not more than 50 miles apart. Some time ago I had a definite impression that such short intervals were unnecessary. My staff took a very effective means of curing me of that impression. I was taken on an inspection trip of the route from Montreal across Northern Ontario. While flying at 6,000 feet the single engine of our plane suddenly sputtered a few times and died. My first thought, of course, was, where would we land? I looked about me, and in all directions I could see nothing but spruce trees, and no sign of a landing field. After a minute or two, the engine started again, and my anxiety was relieved. The pilot explained later that one gas tank had run out and that he had failed to turn on another in time to keep the engine running continuously, but in any event he had convinced me that we needed landing fields at least 50 miles apart, and more frequently if possible.

Toward the end of July, I expect to fly over our new route from Montreal to Vancouver. I will use a twin-engine plane similar to those that will be standard equipment on the route. The plane will have a cruising speed of about 200 miles per hour and will carry gasoline for about 1,000 miles of flight. The distance to be covered will approximate 3,000 miles, and I anticipate that by leaving Montreal in the morning I will be able to dine in Vancouver the same evening at the usual time. I will make the trip in safety, for, in the almost impossible event of both engines failing, I will always be within gliding distance of a well-built emergency landing field. For most of the distance I will be on a radio beam and thus be independent of visibility. I will ride comfortably in a well air-conditioned plane, with most comfortable seats that can be inclined at any angle I wish for reading or sleeping.

The regular schedule will provide for leaving Montreal at eight o'clock in the evening, flying across to Winnipeg in the night, and arriving at Vancouver around the following noon. The return trip will leave Vancouver about three p.m. and arrive in Montreal early next morning. Toronto will be similarly served by planes leaving there in the evening and arriving in Vancouver next noon. Connections will be made at several points with planes for the United States, and the many Northern routes now in operation will have connections with the main artery of travel. Within the next two years Canada will have a modern airline service available for all its principal cities. When that time comes, I trust that some proper recognition will be given to the engineering genius that has been expended to provide the facilities that have made these routes possible.

Some of us are apt to think of an airline as made up of only modern planes and their pilots. The fact is that about ten men are required on the ground for every one man who operates in the air. Overhaul shops, equipped with expert mechanics, must be provided for regular servicing of all planes and engines; and provision must be made for handling passengers and mail expeditiously at stopping places. An aviation route is similar to other competing transportation systems in the complexity of its problems and its need for an experienced personnel. In the neighbouring United States a most efficient practice has been built up over the past ten years at considerable expense, and Canada is fortunately in a position to profit by the experience gained there. It is our intention to obtain as head of our Trans-Canada Air Lines a man fully conversant with the experience of the United States and who will be able to guide our development in a way that will permit us to profit by United States practices in parallel operations.

There has been much discussion recently about the safety of travel by air. Modern invention has provided a very high degree of safe operation. I have every confidence that Canadians generally will adopt this new form of travel, and that ample traffic will offer as soon as the route can be placed in operation.

The Trans-Canada service shortly to be placed in operation will tie together existing operations, and furnish Canada with an airline network that will reach all parts of our vast Dominion. Facilities for rapid travel should do much to knit together our scattered population, and to make for better understanding between far distant centres. There is a demand for this service both for mail and passengers, and I am firmly convinced that the rate at which traffic will increase will tax the efforts of those charged with providing adequate service.

While we in Canada are creating an inter-urban route across this country, our associates in England and in the United States are co-operating to conquer the North Atlantic by air. It is expected that the first of the trial flights across the Atlantic will be undertaken simultaneously from England and from the United States during the latter part of next week. Montreal has been designated as the Canadian terminus of this route, and Canada has undertaken to be ready to transport passengers and mail from the North Atlantic airships across Canada to Vancouver. There can be little doubt that an extension of the route westward will follow, and that within a few years Canada will be an important link in an all-British air route which will touch every country in the British Empire. Developments in modern engineering have removed all doubt that such a route is feasible. Perhaps no more spectacular engineering triumph has been reported at this gathering.

# North Atlantic Air Service[1]

## London - Montreal

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

**Deals with factors affecting the success of a commercial air service across the north Atlantic, such as potential traffic, choice of route, weather conditions, terminal organization and facilities, aids to navigation, and type and performance of aircraft.**

The outstanding feature of all recent developments in transportation is speed and in no branch, perhaps, is this feature so impressive and so important as in transport by air.

While, at the moment, air transport is restricted somewhat by meteorological and topographical factors, as are older methods of transportation to a greater or less degree, on reaching its full development in the near future, air transport will undoubtedly surmount these limitations. Full advantage can then be taken of the principal advantage of air transport, namely, speed. Air transport lines of the future will follow the great circle routes unhampered by weather or terrain.

Canada, with respect to some of the more important of the future great circle air routes, occupies a geographical position of great importance. Even before air transport reaches complete independence, and during the development of inter-continental air routes, the geographical position of the Dominion is one of no little strategic value.

It is proposed in this paper to discuss one of the inter-continental air routes, now in process of establishment, of great importance to Canada, that across the North Atlantic ocean.

### Historical

The North Atlantic ocean, the great barrier to communication between Europe and North America, has been successively overcome by sailing vessels, steamships[3] (1827) submarine telegraph (1858), wireless telegraphy[4] (1901), wireless telephony (1915) and aircraft (1919). During 1936, the first regularly scheduled commercial air transport service over the North Atlantic was operated.

Since the first flights across the North Atlantic in 1919, some 85 crossings have been made by air. Of these, 65 were non-stop flights and 20 were made by stages. The non-stop flights included 31 by airship and 34 by aeroplane. Of the latter, 8 were solo flights, 26 were made from west to east and 8 from east to west. Some 68 persons have crossed the North Atlantic by aeroplane, non-stop, and 269 by stages, and about 2,682 by airship. The crossings are listed in Appendix I, and the courses of some of the more important are plotted in Fig. 1, reproduced from a previous paper.

Generally speaking, the crossings by aeroplane have been, with a few notable exceptions, purely stunt flights, undertaken with no scientific or technical objective, and have added little or nothing to our knowledge. In most of these flights, the aeroplane was more or less seriously overloaded compared with normal airworthiness standards. The exceptions include the first non-stop crossing of Alcock and Brown, on June 14th, 1919, the first solo flight of Lindbergh, the first westward crossing of Huenefeld, the east-west flight of Costes and Bellonte, the exploratory flights of von Gronau and of Colonel and Mrs. Lindbergh

[1]Without in any way wishing to detract from the impressive performances of airships over the North and South Atlantic, this paper is confined to consideration of an air service using heavier-than-air aircraft.

[2]The views and opinions expressed in this paper are entirely those of the author.

[3]It may be noted in this connection that the Royal William, a wooden vessel 176 ft. long, of 200 hp., built in Quebec in 1831, crossed to England in 1833 in twenty-five days and was the first ship to make the eastward crossing wholly under steam.

[4]The first transatlantic signal, the letter S, transmitted from Poldhu, Cornwall, was received at St. Johns, Newfoundland, by means of an aerial supported by a kite, on December 12th, 1901. Marconi was immediately invited by the Canadian Prime Minister to proceed to Canada and, as a result, a contract was entered into for the establishment of a transatlantic wireless service between Canada and Great Britain. The first messages were exchanged between the Governor-General of Canada, the Earl of Minto, and King Edward VII, in 1902, and in October 1907, the first long distance commercial service in the world was inaugurated between Glace Bay, N.S., and Clifden, Ireland.

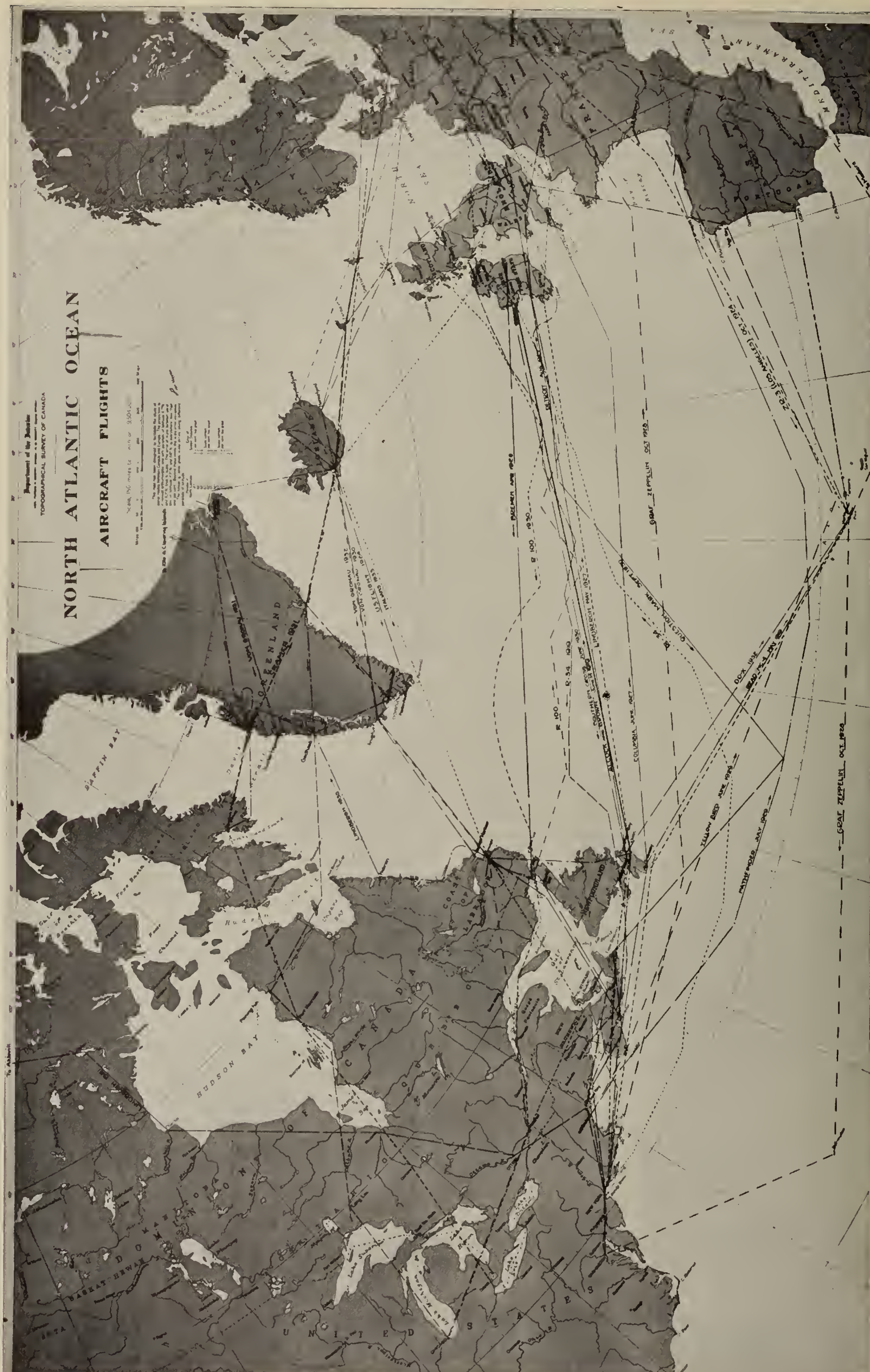


Fig. 1—Aircraft Flights, North Atlantic Ocean.

and the recent flights of the Diesel engined Dornier Do-18 flying boats.

The first and only commercial air service operated to date over the North Atlantic is that of the German airship LZ-129 (von Hindenburg) which, during the period May-October, 1936, flew ten scheduled round trips between Germany and the United States, carrying passengers, mail and express.[5]

### The Barrier of the Atlantic

Regular air services now connect most of the major land bodies of the earth, with three notable exceptions. Although many flights have been made across the North Atlantic, and a smaller number across the North Pacific, regular commercial services by aeroplane are not yet in operation between North America and Europe, Asia[6] and Australia.

The possibilities in the operation of a commercial air service across the North Atlantic have long been recognized and plans for establishment of services have been made from time to time since the first crossings in 1919. Recent years have seen a quickening of interest in the project. Several nations are now actively studying proposals and, in one case, at least, preparations for a service are so far advanced that operation will likely be commenced in 1937.

Considering the inducement offered by the enormous potential traffic, it is evident that the difficulties to be overcome in the establishment of an air service between Europe and North America must be formidable.

The North Atlantic ocean has been termed "the greatest natural obstacle with which air transport is confronted." The barriers to be surmounted in overcoming this obstacle are those due to the length of the land to land flight and to the severe meteorological conditions. Up to the present time, these two have proved unsurmountable obstacles to the establishment of a transatlantic air service.

The minimum land to land distance that must be flown non-stop, if landings are not made on mid-ocean islands, is 1,850 miles, between Ireland and Newfoundland. Solely from the standpoint of non-stop flight, this range presents no particular difficulty for modern aircraft. The economic operation of a commercial service over a non-stop stage of this length and over the open sea, however, does present difficulties at this stage in the development of aircraft. The distance is considerably longer than the longest stage of any commercial air route now in operation and the overseas distance exceeds any flown commercially up to the present time.

It is generally recognized that the meteorological conditions over much of the North Atlantic ocean are, from an aeronautical standpoint, troublesome, not the least troublesome feature being the lack of knowledge pertaining to the upper air. However, as stated by Sir Napier Shaw, it would be difficult to draw a line across the ocean that could be regarded as an impossible course.

General surface climatic conditions over the North Atlantic are to-day reasonably well known. Organized weather reporting from ships at sea, observations at land stations, and the co-operation of the meteorological services of the maritime nations provide more or less adequate

[5]Average figures for this service are:—

| Trip | Miles | Time | Passengers | Crew | Best time |
|---|---|---|---|---|---|
| Westward | 4,351 | 64–35–00 | 48.1 | 56 | 52–48–00 |
| Eastward | 4,091 | 51–53–00 | 53.7 | 56 | 42–52–00 |

[6]The United States have practically completed the organization of a transpacific air service and trial flights have been made, but, at the date of writing, regular operations had not commenced.

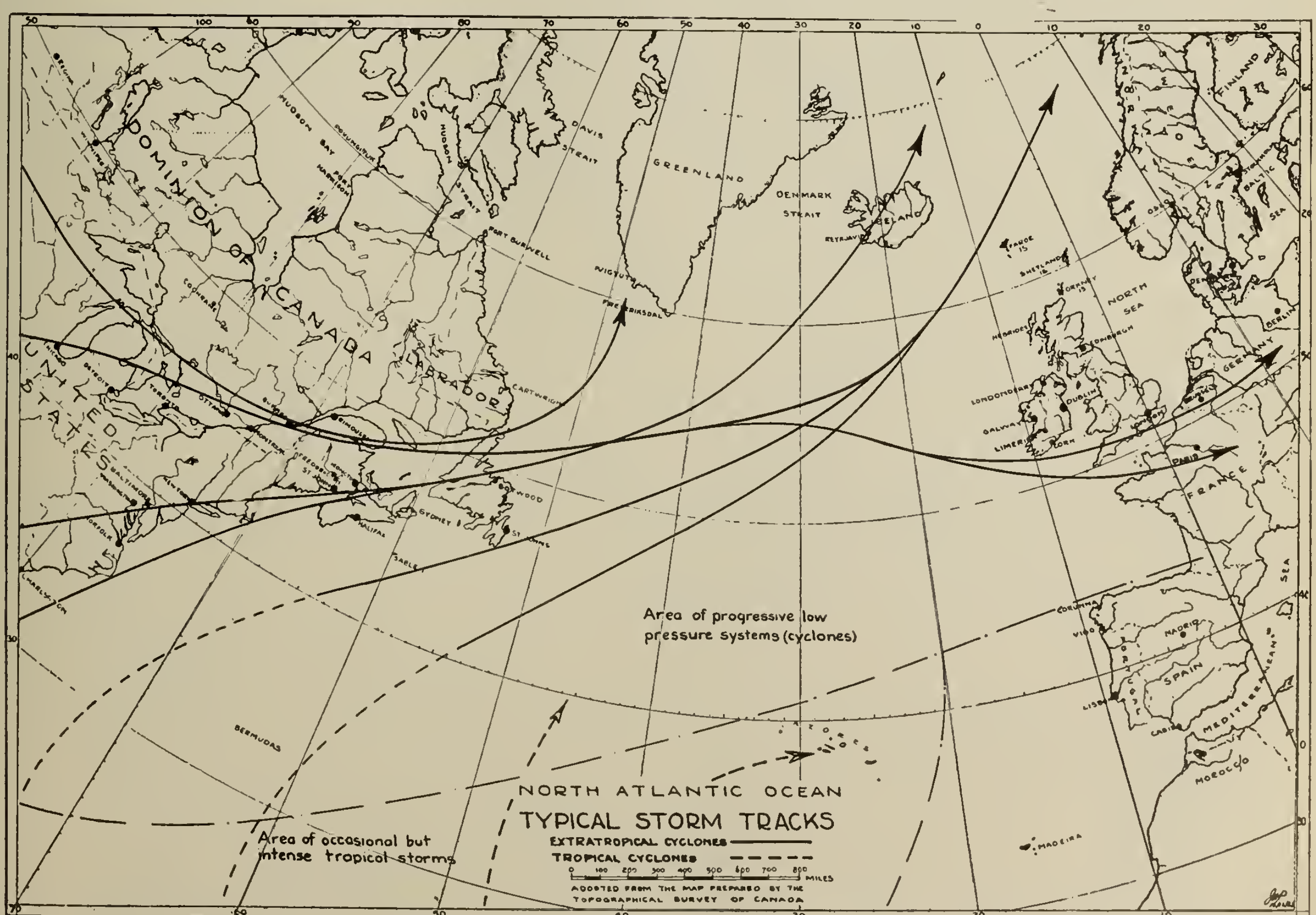


Fig. 2—Typical Storm Tracks.

information for sea-borne transport. On the other hand, knowledge of upper air conditions, so necessary to air transport, is almost completely lacking. The only information available is that collected at coast and island stations, by a few naval vessels and scientific expeditions and that obtained from the relatively few flights so far made.

The stormy character of the Atlantic ocean north of the Bermuda-Azores line is well known. The area below the line, approximately from the Bahama islands to Cape Finisterre, is subject to occasional but intense tropical storms and that above this line is characterized by frequent progressive low pressure systems or cyclones (see Fig. 2).

Perhaps the most striking fact disclosed by a study of the tracks of North Atlantic storms is that a rather well defined corridor is followed from the North American coast to Europe.

The largest number of storms enter the North Atlantic region from the Newfoundland area. Many of these have previously traversed Canada and the Northern United States. Of the storms entering by way of Newfoundland, nearly 50 per cent turn northward toward the west or east coast of Greenland. The remainder move on a course generally somewhat north of east to about midocean. Thereafter, most of these follow paths over the northern parts of the British Isles or north of them, some turn to the north and pass over Iceland and a few veer south to pass over the southern part of the British Isles.

Other cyclonic storms, frequently of great severity, develop in the Florida region or off the Carolina coast and move up the Atlantic coast and across the Atlantic along the corridor already described.

Of over 300 lows studied by Colonel Finley, 10 per cent were traced from the American to the European coast, 21 per cent were observed on one coast or the other and 32 per cent of those reaching the European coast originated over the ocean.

Tropical storms, of which the best known are the hurricanes, originate in midocean north of the doldrum area, move first generally westward and later turn north to pass over the West Indies and Gulf of Mexico. Those forming off the African coast frequently swing north in midocean and later north-eastward toward or north of the Azores. These storms, as a rule, form in September and October and average six or seven per year. They cannot be foreseen since there is little shipping in the region from which they come.

There is a definite seasonal variation in storm frequency. North of latitude 36° N. during the winter (from the middle of October to the middle of April), gales and storms are frequent. Days on which gales (wind force 8[7]

[7] Beaufort Scale

| Beaufort number | Description of wind: Seaman's | Description of wind: U.S. Weather Bureau | Statute miles per hour |
|---|---|---|---|
| 0 | Calm | Light | Less than 1 |
| 1 | Light air | Light | 1-3 |
| 2 | Light breeze | Light | 4-7 |
| 3 | Gentle breeze | Gentle | 8-12 |
| 4 | Moderate breeze | Moderate | 13-18 |
| 5 | Fresh breeze | Fresh | 19-24 |
| 6 | Strong breeze | Strong | 25-31 |
| 7 | Moderate gale (high wind) | Strong | 32-38 |
| 8 | Fresh gale | Gale | 39-46 |
| 9 | Strong gale | Gale | 47-54 |
| 10 | Whole gale (heavy gale) | Whole gale | 55-63 |
| 11 | Storm | Whole gale | 64-75 |
| 12 | Hurricane | Hurricane | Above 75 |

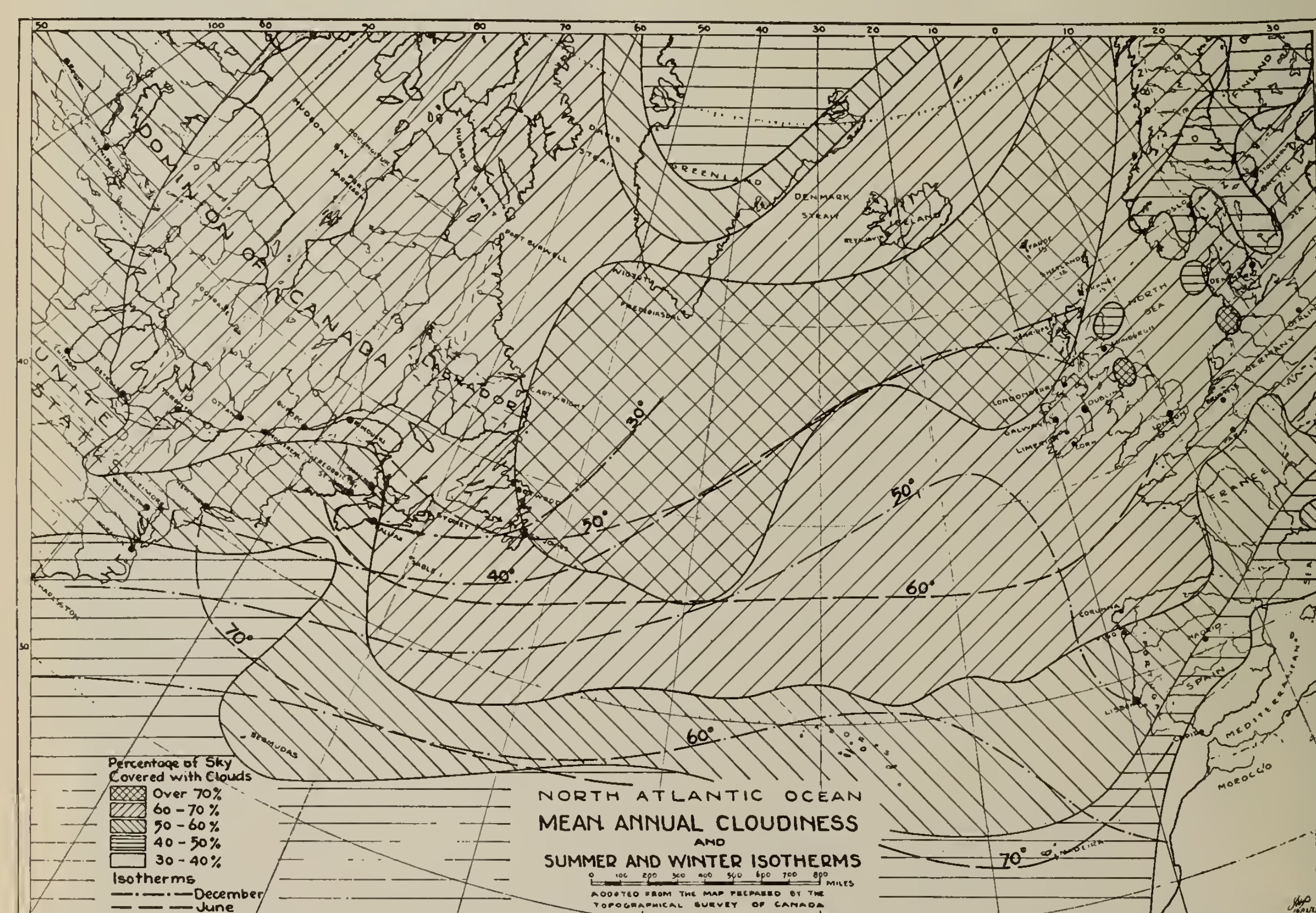


Fig. 3—Mean Annual Cloudiness.

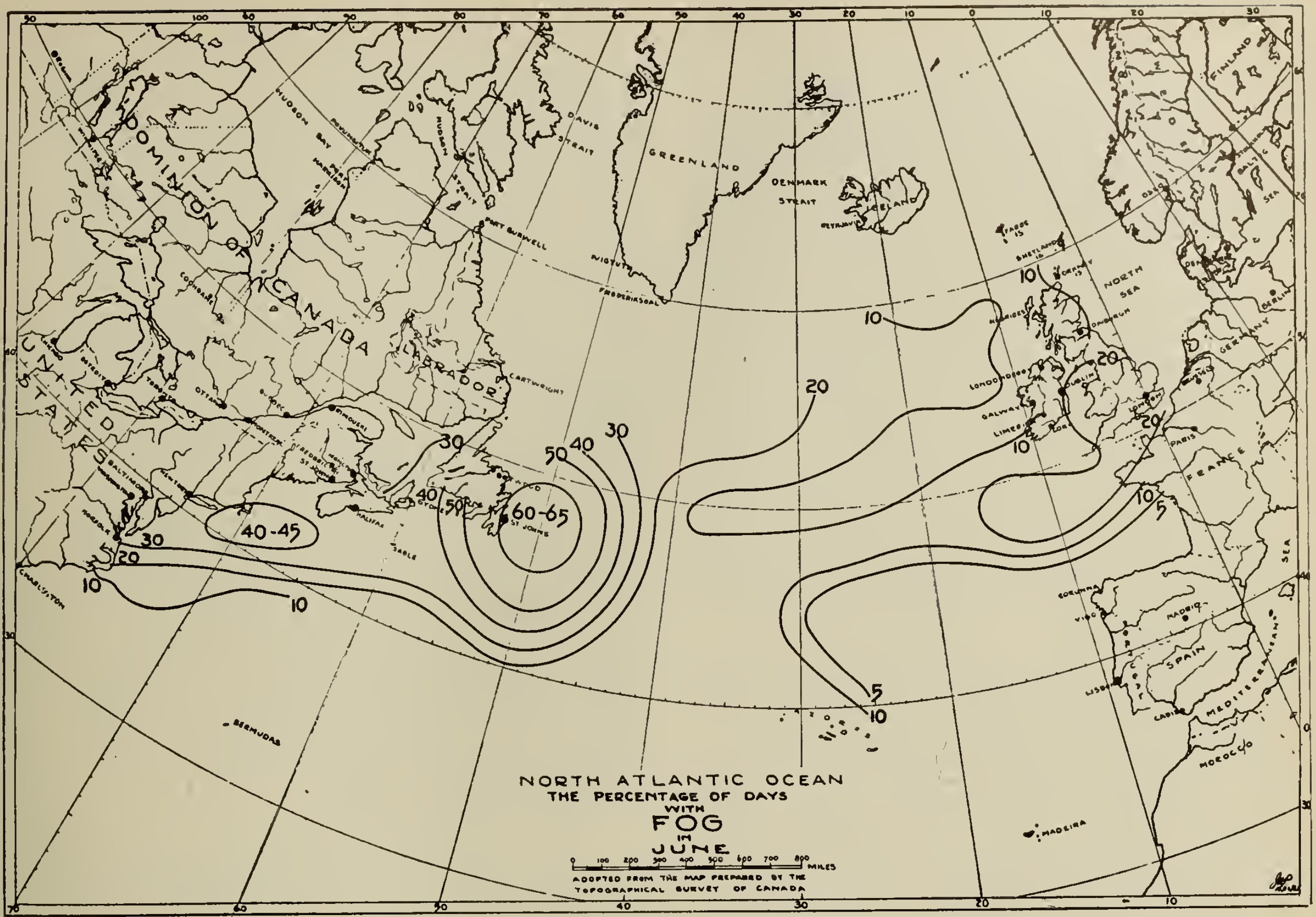


**Fig. 4—Percentage of Days with Fog in June.**

and below) are reported in this region may reach 20 per month; whole gales (force 10) 5 or more and winds of hurricane force (force 12) 1 or 2 and occasionally more per month. There is some indication that the frequency is greater in midocean between longitude 25° and 45° W. than near the coasts.

Information is lacking as to the height to which cyclonic storms extend. Storm areas over the Atlantic have been encountered above 10,000 ft. and in at least one case the top of the storm cloud was estimated to have extended to 20-25,000 ft.

A good deal of information pertaining to North Atlantic surface winds, their strength, direction and frequency has been collected and made available. While the average prevailing wind in the north is westerly, it varies widely in strength and direction. However, winds in the quadrant NW. to SW. predominate.

The wind direction at altitude over the ocean can only be inferred from observations made at coast and a few island stations, knowing that, for the same pressure gradient, surface winds are considerably stronger at sea than on land and blow more nearly parallel to the isobars, and that consequently the increase in speed and change in direction with height are less over the ocean than over land. Also, observed conditions at island stations are applicable to larger adjacent areas than is the case for land stations.

The average veering of the wind with altitude as observed at American coast stations indicates that, up to 2,000 ft., there is a general clockwise rotation and thereafter a veering right and left from the east until, at 12-13,000 ft., wind directions range only from NW. to WSW. Surface winds from the NW. and WNW. change little in direction with altitude. At the same time, the velocity increases with altitude. To illustrate:

A 10-mile E. wind at the surface becomes
at 5,000 ft. a 17-mile SSW. wind
at 10,000 ft. a 20-mile W. wind
at 15,000 ft. a 26-mile WNW. wind

A 10-mile W. wind at the surface becomes
at 5,000 ft. a 23-mile WNW. wind
at 10,000 ft. a 31-mile WNW. wind
at 15,000 ft. a 38-mile NW. wind

Thus easterly winds at the surface are usually shallow.

Another feature of the North Atlantic region is its extreme cloudiness. The cloudiness appears to be related to surface air temperatures. The major axis of the area of greatest cloudiness extends roughly between Newfoundland and the Faroe islands (see Fig. 3) and this line corresponds approximately with the 40 deg. surface isotherm in midwinter and the 50 deg. isotherm in summer. With surface temperatures below 50 deg. in summer, clouds may be expected.

Most clouds apparently lie below 10,000 ft. although some extend higher. The height of clouds may be estimated from the surface air temperature and humidity.

Information regarding the prevalence and seasonal distribution of different cloud types and their relation to thunderstorms, fog and mist would be of considerable value in the operation of ocean air services. Such information, while available in the mass of records of meteorological services from cloud observations made at sea, has apparently not been analysed and published in maps because of its relative unimportance to shipping.

Certain regions of the North Atlantic are characterized by dense and frequent fogs (see Fig. 4). Fogs result when steep temperature gradients of air and water are superimposed, as frequently happens off Newfoundland.

As temperature measurements indicate that the temperature in fog increases from the sea to the top, above a certain height fog is impossible and consequently fogs must be relatively shallow. This conclusion is confirmed by kite observations which show that fogs average in height from 400 to 500 ft. with occasional heights exceeding 1,000 ft. But, should an area of low pressure lie over the fog bank, the low clouds merge with the fog and poor visibility will then extend continuously from the surface to high altitudes.

Air temperatures (see Fig. 3) over the Atlantic, except as they influence other climatic conditions, fog and ice, impose no handicap on aircraft. Atmospheric ice formation is a hazard peculiar to aircraft. For this reason, information pertaining to it has not been collected in the past. Icing has been encountered by aircraft over the Atlantic, even in summer and well south of the steamer lanes.

From the standpoint of icing, a knowledge of upper air temperatures and humidity is important. Overland temperatures decrease roughly 1 deg. per 328 ft. altitude, but this rule is subject to wide variation with latitude and even for the same latitude.

Precipitation over the northern portion of the North Atlantic is high. About one-half of the observations from ships in this region report precipitation. Except as it relates to the formation of atmospheric ice, precipitation is not important to modern aircraft.

Thus the meteorological handicap peculiar to the North Atlantic is the frequency of storms, fog and cloud characterizing certain regions. The prevailing westerly winds, although possibly stronger over the Atlantic, face any east-west service and the extent of the ice hazard has yet to be determined.

The severity of the climatic conditions has not prevented the development of transatlantic shipping until the volume of traffic now exceeds that across any other sea, nor should it obstruct indefinitely the establishment of transatlantic air services.

### Ship-Shore Services

In the past, lacking equipment capable of operating a transatlantic air service, efforts were made, with the available aircraft, to secure some of the advantages of air transport, by operating partial services in conjunction with steamers on the transatlantic routes.

Canada, looking forward to the time when aeronautical development would permit the establishment of transatlantic commercial air services, commenced, in 1927, experimental ship-shore air mail services. The purpose of these services was fourfold, namely:

1. The exploitation of the favourable geographical position of the Dominion with respect to Europe and steamer lanes, as a result of which, of the 3,350 miles of steamer route between Montreal and Southampton (via Belle Isle) some 1,000 miles are within the relatively sheltered waters of the St. Lawrence waterway.
2. The acquiring of experience in the regular operation of a St. Lawrence air service relative to suitable aircraft types, meteorological conditions, routes, organization and operating technique, which would be valuable when operation of a transatlantic air service commenced.
3. The speeding up of the delivery of incoming and outgoing overseas mail.
4. The demonstration of the benefits to be derived from even such a partial air service and the awakening of public opinion to the importance of Canada's position relative to the principal transatlantic air route and to the need for active Canadian participation on a major scale in the development of this route.

Aircraft of the Royal Canadian Air Force made experimental flights between Montreal and Father Point in the autumn of 1927 to advance the delivery of transatlantic mail carried by steamers using the St. Lawrence route. Ten flights were made (8 by aeroplane, 2 by seaplane) and a total of some 2,500 lb. of mail were carried with an average advance in delivery of incoming mail of thirty hours and of outgoing mail of three and a half days.

The success of these experimental flights resulted in the establishment of a regular contract air mail service between Montreal and Rimouski on May 5th, 1928, which has been operated each year since, during the season of St. Lawrence navigation (May-November). The mail is carried by aeroplane and transferred to and from the steamer by pilot tender at Father Point. Up to 800 lb. of mail are carried per flight. A brief record of this service is given in Appendix II.

In December 1929, primarily to continue the summer Montreal-Rimouski service, an experimental service between Montreal and Moncton and Saint John, N.B., was begun. Daily trips (5 days per week) were made by way of Quebec, south shore of the St. Lawrence river, Edmundston, St. John river valley to a point northeast of Woodstock, Fredericton and Moncton. Overseas mail was transferred at Moncton for carriage by rail to Halifax. In 1930, the service terminated at Moncton and on June 1st, 1931, was suspended when a general reduction was made in Canadian air mail services. A brief record of this service is also given in Appendix II.

Later, consideration was given to the extension of the St. Lawrence service to the Strait of Belle Isle and an experimental flight was made in 1930 by two aircraft of Canadian Airways Ltd. from Quebec to Bradore Bay (see Fig. 5) on the Strait just within the Canadian boundary. The 785 miles were flown between 8.30 a.m. and 5.00 p.m. and some 1,000 lb. of mail transferred to the *Empress of Australia* which had sailed from Quebec the previous day, effecting a saving in time of twenty-four hours.

In 1932, in conjunction with the Imperial Conference in Ottawa, a ship-shore air mail service was operated between Red Bay on the Strait of Belle Isle and Ottawa. Ten flights were made by aircraft of the Royal Canadian Air Force.[8] A typical schedule is given in Appendix II. Mail was delivered in Ottawa twenty-seven hours before the ship docked at Quebec, thereby saving thirty-six hours in the delivery of overseas mail. Mail posted in London was delivered as follows:

| | |
|---|---|
| In Montreal | 102 hours later |
| In Ottawa | 104 hours later |
| In New York | 106 hours later |
| In Vancouver | 151 hours later |

Ship-shore services by means of aircraft catapulted from the ship have also been operated from steamers plying between Europe and America. The first liner to be equipped with a catapult for this purpose was the *Ile de France* of the French line. The catapult[9] was mounted on the stern. The first flight was successfully made on August 13th, 1928, when the amphibian aircraft, with wheels removed, carrying three sacks of mail was catapulted some 400 miles at sea and landed the mail at New York sixteen hours before the ship docked. Longer flights, up to 800 miles, using a larger aircraft, were planned, but no further information on the service is available.

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[8]Another demonstration of the possibilities of Canadian air mail was given in August 1933 when letters were flown from Vancouver to Quebec, placed on the *Empress of Australia*, and reached London in seven days instead of the twelve days ordinarily required for the 6,000 miles.

[9]For details of catapult and aircraft, see Appendix III.

In 1929, the Norddeutscher Lloyd liner *Bremen* was equipped with a catapult mounted on a turntable between the funnels and, in 1930, the *Europa* was similarly equipped.

The service was operated under the joint auspices of the Norddeutscher Lloyd, the Deutsche Luft Hansa and the German Post Office. The aircraft was launched at distances ranging up to about 1,500 miles, but averaging 500-700 miles from the English or American coast, depending on prevailing conditions and, eastbound, flew to Southampton and thence to Bremerhafen, and, westbound, flew via Cape Race to Sydney to land Canadian mail and thence to New York. Occasional landings were made at Boston. While proposed, the despatch of mail by seaplane to overtake the ship was, insofar as is known, not attempted.

The extra fee charged for letters, for carriage by this service, was 75 pfg. per 20 grammes. The British and United States Post Offices did not accept mail for dispatch by the service.

In spite of an early accident, when a seaplane was lost near Newfoundland, the service was operated each summer[10] from 1929 to 1935 inclusive. A brief record of the service is given in Appendix IV. The time saving ranged up to forty-eight hours eastbound and up to seventy-two hours westbound. A five-day service between London and San Francisco was rendered possible.

The service has enabled the Deutsche Luft Hansa to gather information regarding Atlantic weather, radio operation and the economic aspects of Atlantic air mail, of great value in planning a transatlantic air mail service.

[10] The catapults were removed in the fall and reinstalled in the spring.

## THE TRANSATLANTIC AIR SERVICE

### Object

The volume of traffic between European ports and the Atlantic ports of North America greatly exceeds that between any other two continents (see Appendix V). That much of this traffic is of a character which demands and is prepared to pay for the fastest possible service and would hence immediately make use of a reliable air service if it were available is evident from the experience of the N.D.L. ship-shore service and from the steady increase in the volume of traffic carried by long distance air services now operating.

Banks and business houses are quick to take advantage of air mail and news film companies, press photographic agencies and similar organizations use air mail whenever possible.

The transatlantic traffic demanding speed will comprise mail, express and passengers and the ultimate objective should be the operation of a reliable, fast, regular, frequent and economical service for this traffic. However, for a number of reasons, the initial service should be confined to the carriage of mail and express.

In the first place, as the figures in Table I indicate, the revenue is greater for mail and express than for passengers. Mail and express require less space and do not require the food, services, facilities, comfort and entertainment demanded by passengers. The mail aircraft is therefore smaller, more compact, less costly to build and operate, and requires a smaller crew than the passenger carrier. Operation for the first few years will necessarily be largely devoted to the acquisition of experience and information


**Fig. 5—Gulf of St. Lawrence.**

and the crews should be free to devote themselves to this work. There is the further consideration that there will be a certain element of risk during the initial period of operation and the carriage of passengers would impose an additional strain on the crews and in addition the loss of passengers would react much more unfavourably on the project than would the loss of mail or express.

Table I

Comparison of Transatlantic Transport Rates

| | Steamer Present average | | |
|---|---|---|---|
| | Nominal | Rate per lb. | Rate per cu. ft. |
| Mail—letter......... | 3c. per oz. | $1.20 | $18.00* |
| Express.............. | 10c. per lb. | 0.10 | 2.00 |
| Passenger........... | $250.00 | 1.00 | † |

| | Aircraft Proposed rates‡ | | |
|---|---|---|---|
| | Nominal | Rate per lb. | Rate per cu. ft. |
| Mail—letter......... | 15c. per ½ oz. | $6.00 | $90.00 |
| Express.............. | $1.00 per lb. | 1.00 | 20.00 |
| Passenger........... | $500.00 | 1.66 | 4.00 |

Based on 40 letters per pound and a weight per cu. ft. of letters equal to 15 lb., i.e., 600 letters per cu. ft.

Based on average express package weighing 20 lb. and occupying one cu. ft. of space.

Based on average weight of passenger and baggage 225 lb.

Based on an allowance per passenger in aircraft of 75 lb. for furniture, galley equipment, food and service and a space allowance of 120 cu. ft.

*Steamers are paid about 50 cents per cu. ft.

†In steamers, excess baggage, over an allowable of 20 cu. ft., is charged for at a rate of 60c. per cu. ft.

‡Suggested by the author.

## Potential Traffic

The present seaborne traffic between European and North American ports is tabulated in Appendix V. In round numbers, the total yearly traffic each way is:

| | |
|---|---|
| Mail—first class............................ | 3,600,000 lb. |
| prints, etc............................ | 17,000,000 lb. |
| parcels............................ | 11,500,000 lb. |
| Passengers.................................. | 300,000 |

Assuming 2½ per cent of the first class mail, 1 per cent of the parcel mail and none of the prints are carried by air, at the rates suggested in Table I, the volume of air mail traffic and revenue per week would be roughly as follows:

| | Traffic per week Total | By air | Rate | Revenue |
|---|---|---|---|---|
| First class........ | 70,000 lb. | 1,700 lb. | $6.00 per lb. | $10,000.00 |
| Prints............ | 325,000 lb. | 0 | 0 | 0 |
| Parcels........... | 220,000 lb. | 2,200 lb. | $1.00 per lb. | $ 2,200.00 |
| Total.................... | | 3,900 lb. | | $12,200.00 |

On a basis of three trips each way per week initially, the capacity of the aircraft would need to be about 1,500 lb. of pay load and the gross revenue would be about $4,000 per trip.

If passengers are to be carried, the figures indicate that about one-sixth of the total passengers travel first class, or about 1,000 per week each way. If 2½ per cent of these travel by air, the number will be 25 per week or, with three trips per week, about 8-10 per trip, yielding a revenue, at the suggested fare, of about $4,000 per trip.

## Flight Schedule

In drafting the flight time-table, many factors must receive consideration, only a few of which will be mentioned here.

The nature of competitive services may largely determine the terminal to terminal time permissible. In this case, with competition confined to fast liners and airships, adequate time advantage will result from a twenty-four to thirty-hour service.

An important factor is the requirement of the traffic. Contemplating mail and express traffic only, times of arrival and departure should be arranged to permit collection and delivery of mail to suit business hours.

Connections with existing services must also be provided for in arranging the schedule.

Difference in time, on a long east-west service such as this, must not be overlooked.

The service being new and experience lacking, proper allowance must be made in the flight schedule for uncertainties and contingencies.

Initially, the schedule must be arranged to make operation as easy as possible for the personnel. The schedule should not be too close to the limit of which the aircraft are capable. The added strain, due to excessive haste and undue emphasis on the maintenance of schedule, may lead to personnel taking unnecessary risks and inevitably to disaster, as has been recently demonstrated.

As take-off is generally easier than landing at night or under conditions of poor visibility, particularly with catapulting, departures should be scheduled at night to permit landing after the oversea flight in daylight.

A suggested schedule is as follows:

*Westbound*

London—depart 8.00 p.m., permitting collection of mail at close of business day.

Limerick—depart 12.00 midnight.

Botwood, Nfld.—arrive 11.00 a.m., Atlantic Standard time, allowing fifteen hours for flight against headwinds.

Montreal—arrive 5.00 p.m., Eastern Standard time, permitting carriage of mail to many Canadian and United States points overnight, for delivery in morning.

Elapsed time—twenty-six hours.

*Eastbound*

Montreal—depart 2.00 p.m., Eastern Standard time, permitting collection of mail at noon.

Botwood, Nfld.—depart 10.00 p.m., Atlantic Standard time.

Limerick—arrive 4.00 p.m., allowing fourteen hours for flight with following wind.

London—arrive 8.00 p.m., permitting distribution of mail, during the night, to many European points, for delivery in the morning.

Elapsed time—twenty-five hours.

This schedule, based on a cruising speed on the ocean crossing of not less than 180 m.p.h. and providing fourteen and fifteen hours for the crossing, allows ample margin for head winds and deviations to take advantage of weather conditions.

With a tri-weekly service initially, the east and west flights would be made on alternate days.

## The Terminals

The bulk of the North Atlantic traffic is between ports in the British Isles and those adjacent to or reached through the English Channel, and Canadian and North Atlantic ports of the United States. In other words, the heaviest traffic flow is between ports serving the thickly populated and industrial region of Europe and ports serving the corresponding region of North America.

Hence, a transatlantic air service, to carry that portion of the inter-continental traffic demanding speed should operate between terminals convenient to these regions and should ultimately, taking full advantage of the freedom of aircraft, follow the shortest and most direct route between these terminals.

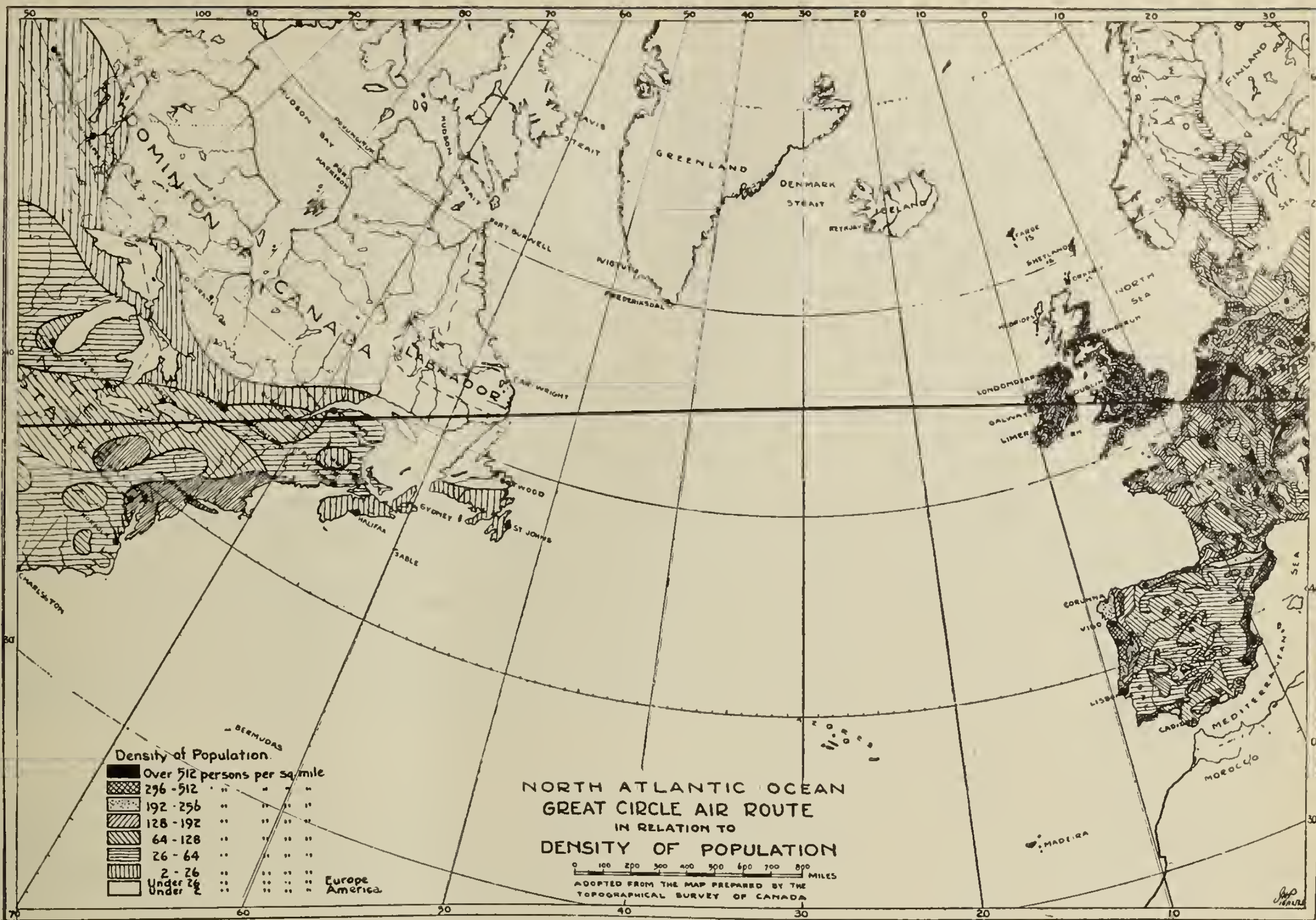


**Fig. 6—Great Circle Air Route in relation to Density of Population.**

The map of Fig. 6, showing density of population, indicates that London is well situated to serve as a distribution point for overseas traffic to the industrial region of Europe and possesses the advantage that it is now the focus of a system of air lines radiating to all parts of Europe. Having due regard for national considerations in the choice of the terminal, it also appears from the map that Montreal is favourably located to serve as the western terminus and centre of distribution for the industrial areas of Canada and of the United States.

### The Route

The ultimate route of the inter-continental air service should therefore be the great circle, between these terminals and the prior routes, established during the development period, should approach the great circle as closely as the capabilities of aircraft at the time permit limitations of range, weather and topography to be overcome.

The courses flown and the air routes proposed across the North Atlantic have been selected generally to circumvent the length of the non-stop oversea flight and to take advantage of favourable or avoid unfavourable weather, or for both reasons. Most successful aeroplane crossings eastward have been from or by way of Newfoundland to take advantage of the short sea crossing and favourable winds and, in the case of flights from the United States, the opportunity, afforded by the long coast flight, to check instruments and motor. All early flights were made in the least stormy season of the year and few, if any, flights have been made starting irrespective of weather conditions. In Fig. 1, are plotted the courses of a number of the more important flights that have been made.

The air routes flown or proposed may be broadly classed as northern, southern and direct.

The northern or Arctic routes are by way of Iceland and Greenland. The most practical of these routes is probably the following (see Fig. 7): London-605[11]-Shetland islands (or Orkney islands)-220-Faroe islands-485-Reykjavik, Iceland-780-Frederiksdal, Greenland-630-Cartwright, Labrador-630-Shediac, N.B.-435-Montreal.

Since the navigation of the North Atlantic was first studied on a scientific basis by Maury early in the nineteenth century, there has been a tendency to recommend shipping routes farther and farther south, despite their great length, to avoid icebergs, fog and storms.

Similarly, the southern air routes, flown or proposed, and based on the Azores, have been selected, not so much to reduce the length of the overseas flight, since little, if anything, is gained in this respect, as to take advantage of more favourable weather conditions.

The southern routes are:

1. That by way of the Azores and Bermuda, recommended by the Hydrographic Office of the U.S. Navy Department (Pilot Chart of the Upper Air—North Atlantic ocean) and partially flown by the Graf Zeppelin in October, 1928. From London to Montreal, this route would be: London-290-Brest-400-Corunna-320-Lisbon-1,050-Horta, Azores-2,050-Bermuda-800-New York-340-Montreal.

   The U.S. Hydrographic Office also recommended routes from the Azores to Cadiz, Brest and Plymouth. Corunna is also a possible European landing point from the Azores and Norfolk and Baltimore alternative points of landing from Bermuda.

[11]Distances are approximate and in English miles.

2. That direct to New York from the Azores, roughly following the New York-Mediterranean steamer lanes, a distance of 2,370 miles.
3. There is also the intermediate route by way of the Azores and Newfoundland, followed on the first Atlantic crossing in 1919 and on several flights since. This route is Lisbon-1,050-Horta, Azores-1,350-St. Johns, Nfld.-355-Sydney, N.S.-660-Montreal.
4. To take advantage of the better weather conditions there existing, routes still further south have been suggested (Verle and Viant 1927, Bleriot 1927). The following commercial route was recently proposed by Musella[12]:—Lisbon (Cadiz in winter)-600-Madeira-1,430-28-0-0 N., 40-0-0 W.-920 (via 28th parallel)-28-0-0 N., 55-0-0 W.-660-Bermuda-800-New York.

Some flights have been made between Europe and North America by way of Africa, the South Atlantic and South America.

The great circle route between London and Montreal crosses Ireland and Newfoundland and passes down the St. Lawrence valley. The approximate length is 3,250 miles. This route is the shortest and therefore the fastest and the land to land distance compares very favourably with that along other practicable routes.

For reasons already mentioned, most transatlantic flights by aeroplane have closely approximated the great circle route.

The great circle route is the commercial air route to be ultimately used when the development of aircraft permits. Immediate complete utilization, non-stop, of the route is impracticable owing to the present limited long range carrying capacity of aircraft which necessitates intermediate landings and imposes limitations on the choice of the location of the intermediate airports. In addition, for the present at least, it is desirable that the transatlantic route connect with and utilize the trans-Canada airway.

To meet these restrictions, intermediate bases in Ireland and Newfoundland must be utilized and the probable route of the air service planned to be inaugurated in 1937 is London-70-Southampton-340-Limerick, Ireland,-2,010-Botwood, Nfld.-470-Shediac, N.B.-435 (via trans-Canada airway)-Montreal.

This route deviates but little from the great circle and its length, 3,325 miles, is consequently little greater than the 3,250 miles of the great circle. At the same time, the length of the oversea flight is practically the same as for the great circle.

The most suitable of the foregoing routes is the one which best permits the requirements of the service—reliability, speed, regularity, frequency and economy—to be met. With the limitations of present day aircraft, all of these requirements will be influenced to a greater or less degree by the length, overall and oversea, and climatic conditions. However, while possible, it is improbable that weather conditions along a shorter transatlantic route would be so much more difficult as to necessitate heavier, slower and more costly aircraft, requiring a longer time for the route than would the lighter, faster and less expensive machines permitted by the more favourable weather of a longer route.

The figures of Table II emphasize the advantage of the great circle route and routes approximating it with respect to overall length. From this standpoint, the northern route is superior to the Azores routes. The shortest of the latter is 30 per cent, or over 1,000 miles longer than

[12] Aeronautica 12, 1932, pp. 1024-37.

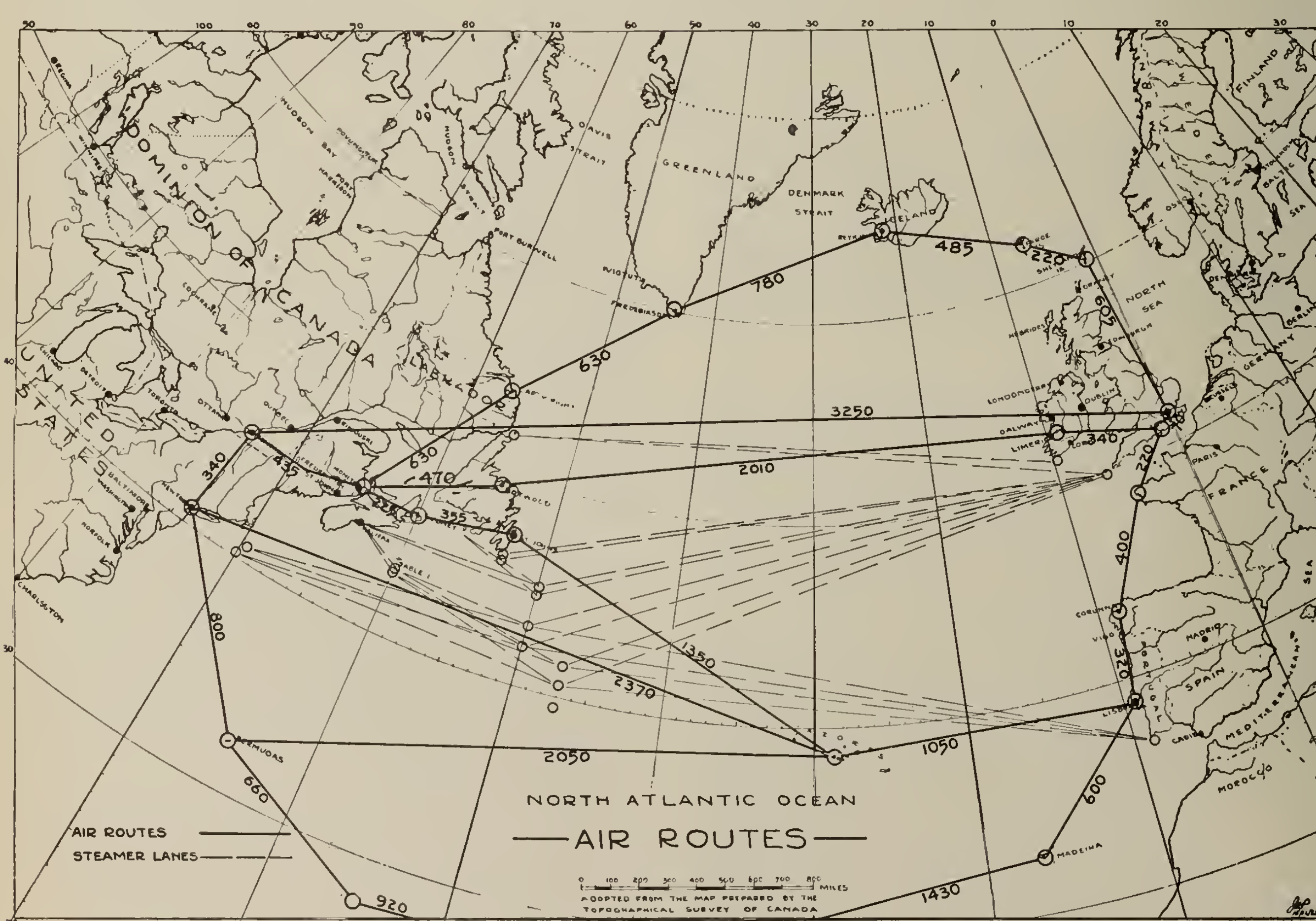


Fig. 7—Air Routes.

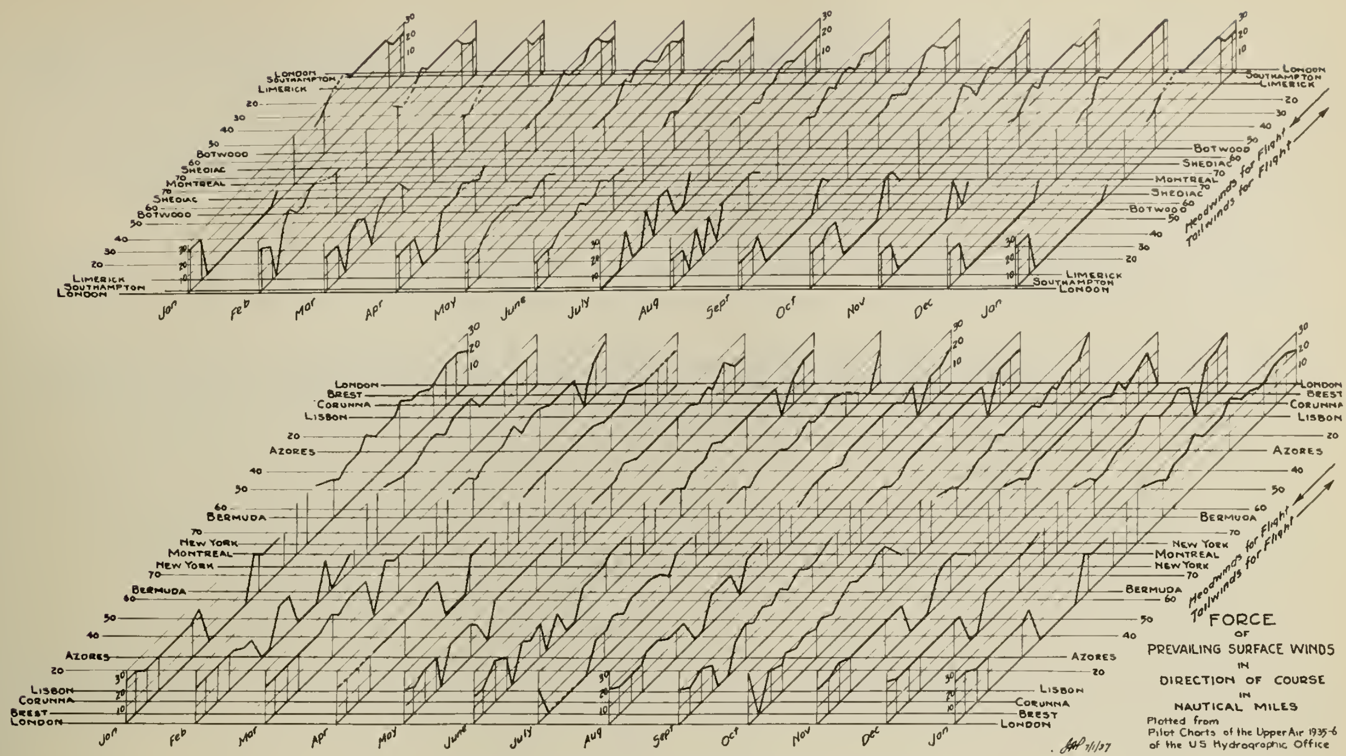


**Fig. 8 —Force of Prevailing Surface Winds.**

the proposed direct route. The overall length of the route, in its bearing on the time from terminal to terminal, is a highly important factor, in view of the keen competition to be met from modern transatlantic steamships and airships.

TABLE II

COMPARISON OF ROUTES—LONDON-MONTREAL

| Route | Overall length miles | Maximum oversea distance miles |
|---|---|---|
| *Northern* | | |
| By way of Iceland-Greenland-Labrador..... | 3,785 | 780 |
| *Southern* | | |
| 1. By way of Azores and Bermuda.......... | 5,250 | 2,050 |
| 2. By way of Azores and Mediterranean steamer lane.......................... | 4,770 | 2,370 |
| 3. By way of Azores and Newfoundland.... | 4,425 | 1,350 |
| 4. By way of Madeira and Bermuda......... | 5,760 | 3,610 |
| *Direct* | | |
| 1. Great circle............................. | 3,250 | 1,870 |
| 2. By way of Limerick and Botwood........ | 3,325 | 1,900 |

While the longest oversea flight of the Arctic route is much shorter than that of any of the others (unless artificial aids are used), it is considered otherwise impracticable for reasons to be given. The 1,350 mile oversea flight between the Azores and Newfoundland is shorter than the 1,900 mile Ireland-Newfoundland flight, but the former route is 30 per cent longer than the latter and will be seen to possess little if any advantage from a weather standpoint. Any advantage possessed by the Madeira route is more than offset by its much greater length and the long oversea flight, and the Azores-Bermuda route suffers from the same disadvantages to a lesser extent.

Thus, on a basis of overall length, the direct route possesses marked superiority, while its inferiority in respect to length of oversea flight, as compared with two of the routes, is more than offset by its superiority in other important respects.

### THE WEATHER

Comparison of the different routes from the standpoint of weather will be confined to two only, the direct and the southern, by way of the Azores and Bermuda, for the following reasons:

Northern, or Arctic routes, have been flown a number of times (see Fig. 1). From the experience of these flights and other available information, it is concluded that these routes, despite the shortness of the oversea flights, are impracticable for regular commercial operation, certainly, in the near future. The disadvantages of the northern routes were dealt with at some length in a previous paper.[13] Such further information as has become available confirms the original conclusion as to the impracticability of the routes. Briefly summarized, the disadvantages of the routes are:

1. Length. The routes lie far from the great circle connecting the thickly populated industrial regions. They are therefore much longer and the resulting greater time between terminals nullifies the principal advantage of air transport, namely, speed.
2. Lack of meteorological information and services (including ships as a source of weather reports) and of reliable charts and maps.
3. Climatic conditions including radio and magnetic difficulties.[14]
4. Difficulties of terrain.
5. Difficulty and cost of establishing and maintaining the necessary ground facilities.

The principal disadvantage of the extreme southern routes is their great length. While the weather is possibly

[13]Transatlantic Air Transport, The Engineering Journal, June 1935, p. 305.

[14]In addition to those mentioned in the previous paper, these conditions include Arctic fog and ice (Amundsen-Ellsworth-Nobile expedition 1936) frequent fog off east coast of Iceland and off the Labrador coast and summer fog south of Cape Farewell.

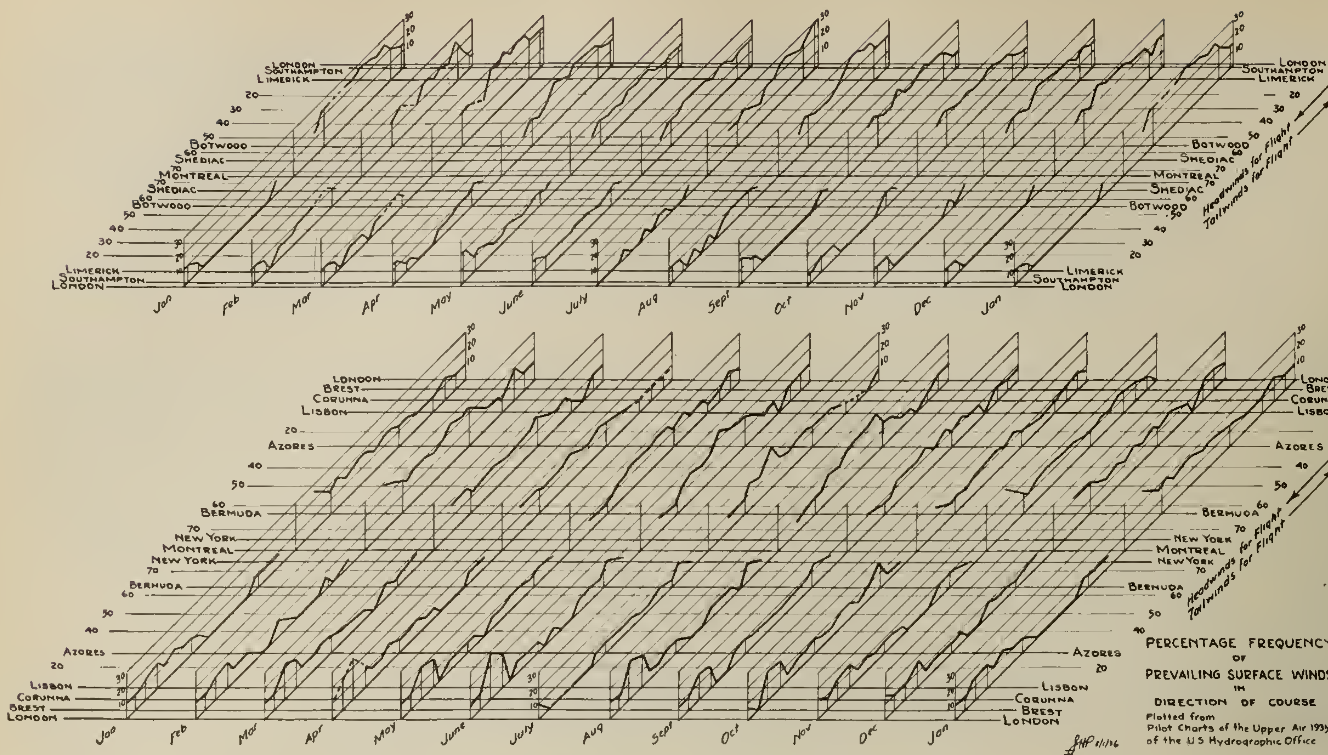


**Fig. 9—Percentage Frequency of Prevailing Surface Winds.**

generally more favourable, there is the hazard of violent tropical storms. These storms are difficult or impossible to predict due to the lack of shipping in and to the south of the region. The length of the oversea flight is generally large.

The route from the Azores direct to New York possesses no advantage from a weather standpoint over the Azores-Bermuda route and the length of the oversea flight is formidable at present. It is somewhat shorter than the Bermuda route, but it is 1,200 miles longer than the direct route. There is the advantage of the presence of shipping since it lies near the steamer lanes.

The one advantage of the Azores-Newfoundland route is the short oversea flight. Otherwise it is long and experiences much the same weather as the direct route. Indeed it traverses the region of greatest fog frequency southeast of Newfoundland (see Fig. 4).

A brief comparison of the weather of the two remaining routes, the direct and the southern by way of the Azores and Bermuda, follows:

*Headwinds*

The strength and frequency of surface head and tail winds for the two routes are plotted in Figs. 8 and 9. Lacking information pertaining to upper air conditions over the Atlantic, the routes must be compared on a basis of surface winds and the known variation with altitude over land.

For the direct route, surface headwinds on the westward flight range from 20 to over 30 m.p.h., with a frequency averaging 20-30 per cent and, on the eastward flight, are, for six months, largely zero and for the remainder of the year average 20 m.p.h., with a frequency of about 20 per cent.

Headwinds average generally over 20 m.p.h., with a frequency of 10-20 per cent on the westbound flight over the whole of the southern route except near Lisbon. Eastbound, the headwinds average 20 m.p.h., with a frequency of about 10 per cent except for sections between longitude 40 and 60 W. where the headwinds drop to zero.

On a basis of upper air observations at American coast stations (see Fig. 11), the westerly winds at 10,000 ft. will range from nearly 40 m.p.h. in winter to about 20 m.p.h. in summer and in frequency from 30-20 per cent. The upper air records for European coast stations are less clear. It appears that, at western stations in England, westerly winds range from 20-25 m.p.h. at 5,000 ft. with frequencies from 40-20 per cent. At the latter stations, easterly winds at altitude are more commonly recorded.

While only direct head and tail winds for the courses have been plotted, the effect of cross winds should not be ignored. A wind from any direction in either quadrant to right or left of the direct head wind and even slightly aft of a direct cross wind, in effect, reduces the distance made good per hour. In a general way, along the ocean section of the direct route, winds from N. to W. to S. predominate in strength and frequency, with west winds generally rather stronger and more frequent than others. Except near the coasts, along the ocean section of the southern route, the strength of the different winds, other than E. and possibly SE., is largely the same, with the frequency higher in the western than in the eastern quadrants.

It should also be remembered that, at altitudes over 12,000 ft., winds probably will range only from NW. to WSW.

As head winds become tail winds for flight in the opposite direction, the disadvantage of the one becomes the advantage of the other. However, tail winds assist less than head winds of equal speed retard flight.

The percentage of calms, light airs and variable winds at the surface (see Fig. 10) averages about 5 per cent for the direct route and 10 per cent for the southern route.

To summarize, on the westward crossing, the head winds encountered are up to 10 m.p.h. stronger and of frequency 10 per cent greater on the direct than on the southern route, but this handicap is experienced for 3,250 miles instead of 5,240 miles (or for 1,870 miles of open sea crossing instead of 3,900 miles from Lisbon to New York).

Eastbound, the average strength of the head winds is about the same for the two routes, but the frequency is less for the southern route. However, the sections experiencing no head winds when eastbound are longer and this condition extends over a greater part of the year on the direct route than on the southern route. Here again the additional 2,000 miles of the southern route must be considered.

In view of the foregoing, the adverse effects of head winds should, on the whole, be more serious for the southern route.

*Storms*

The direct route lies wholly within the region characterized by cyclonic storms (see Fig. 2) and the storm tracks largely follow the route. The occan section of the southern route between Portugal and longitude 20 W. lies wholly outside the cyclonic storm area. The leg between Bermuda and New York crosses the storm corridor up the Atlantic coast. Between longitude 20 and 40 W., the route passes the region subject to occasional but intense tropical storms. Local thunderstorms are also prevalent along the route.

From Fig. 10, it will be apparent that the percentage of days on which winds of gale force and over may be expected ranges, for the direct route, from an average of 1 or 2 per cent in summer, to over 10 per cent in winter, the frequency being highest for the section from the Irish coast to longitude 40 deg. W. where it may reach 15 per cent. The gale frequency is zero for much of the southern route in summer and averages less than 5 per cent in winter. The frequency is highest for the sections in the neighbourhood of longitude 50 deg. W. and of New York and may exceed 10 per cent in these regions.

Thus, along the direct route, the storm frequency is high. Storms are also frequent near the coasts, and particularly the American coast, on the southern route and a section of this route is subject to tropical storms.

The handicap imposed by storms will depend on the height to which they extend. Should cyclonic storms be found to extend no higher than 10-12,000 ft., the handicap will not be serious.

*Visibility*

*Fogs*—Figure 12 clearly indicates that fogs are much more prevalent along the direct route than along the southern in spite of the fact that the route passes to the north of the worst fog area (Fig. 4). The southern route is practically free of fog except near the coasts. In the vicinity of New York, fog frequency may be as high as 20 per cent and the Corunna-Brest-London section, particularly the northern portion, is foggy.

The fogs off Newfoundland are dense and frequent, but seldom, even in the south, surmount the cliffs of the shore and are rarely carried inland. There is often a narrow channel of clear water between the fog bank and the shore. Further north, except in the Strait of Belle Isle, fogs, from a navigation standpoint, are no more serious than in other regions.

Lighthouse records show that fogs are frequent on the east and south coasts of Newfoundland, particularly to the southeast, but the frequency never exceeds 35 per cent and is generally much less (see Appendix VI, Table IIa). The west coast is relatively free of fog. The maximum frequency at points on the west coast may be as low as 2 per cent for the worst month. Sunshine is said to be above the average in Newfoundland and precipitation not large and, while reports conflict as to the degree of prevalence of fog, the foregoing records support the conclusion that there are many fog free areas on the west coast and probably in the interior.

Records (see Appendix VI, Table I) indicate that the frequency of fogs in the St. Lawrence valley is small and less than in the region around New York and portions of the European coast area traversed by the southern route.

As the graphs indicate, little actual fog forms at the Azores. However, strato-cumulus clouds often descend and

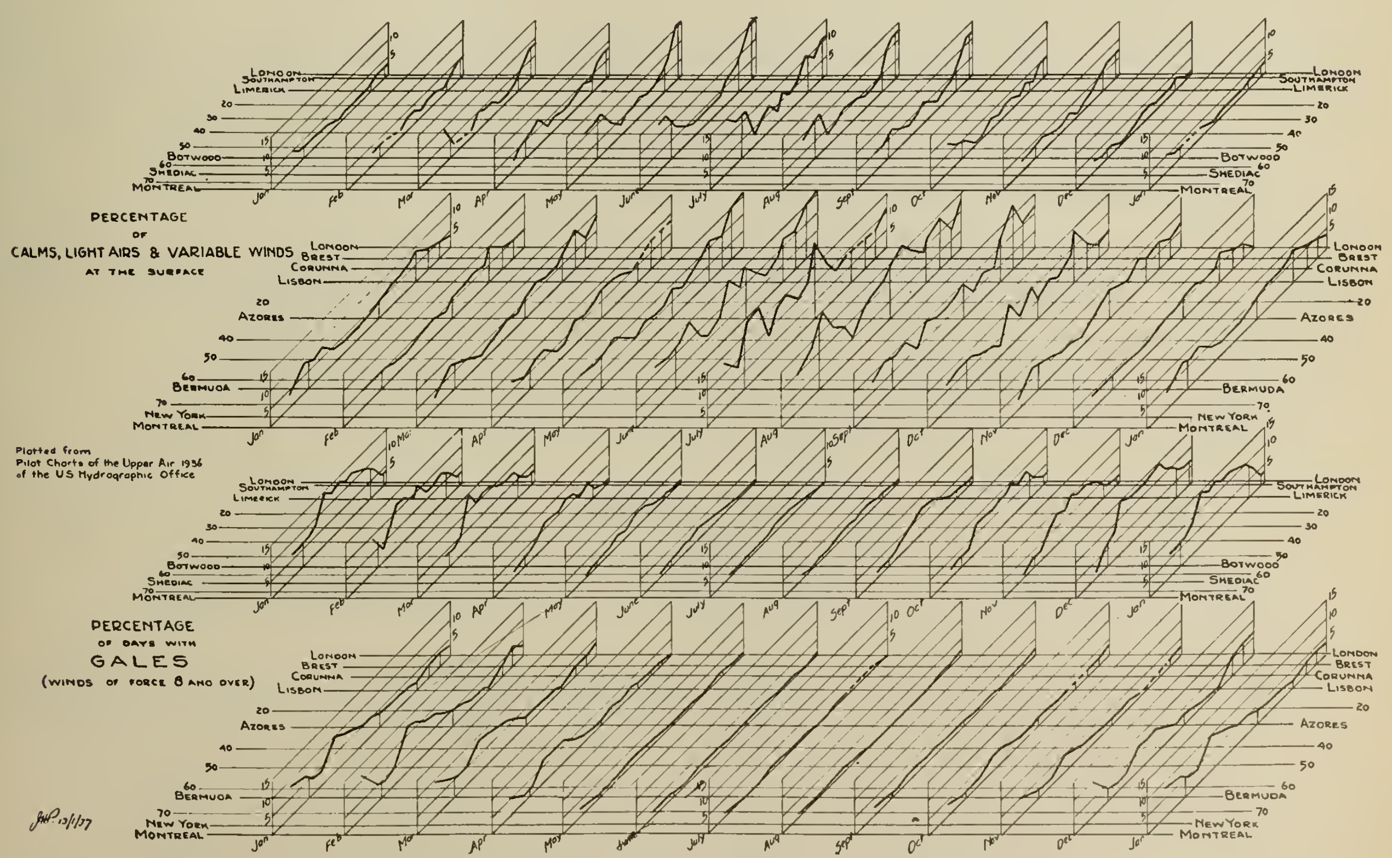


Fig. 10—Percentage of Calms, Light Airs, Variable Winds and Gales.

cover the entire mountainous parts of the islands, rendering them invisible from outside, and even descend to sea level. This occurs principally in June and represents the only lasting "fogs" of the Azores.[15]

*Clouds*—While the region traversed by the direct route is more generally overcast than that of the southern route, the handicap which this greater cloudiness may impose on the direct route will depend upon the height to which the clouds extend and the efficiency of the blind flying equipment.

*Temperatures*

Sea and air surface temperatures along the ocean sections of the two routes throughout the year are plotted in Fig. 12. Generally, sea and air temperatures show the same variations. Air temperatures are higher in summer and lower in winter than sea temperatures for the direct route and are generally lower for the southern route except during May, June and July. Along the direct route, the air temperatures increase from west to east by as much as 10 deg. in winter and 5 deg. in summer. On the southern route, the maximum air temperatures are in the region of longitude 40 deg. W. with a slight gradient to the European coast and Bermuda. A steep gradient of as much as 10 deg. in winter occurs between Bermuda and New York.

For the direct route, temperatures average over 50 deg. in summer and under 40 deg. in winter and, along the southern route, the corresponding average temperatures are nearly 70 and about 50 deg.

[15]According to Director of Meteorological Service of the Azores at Angra.

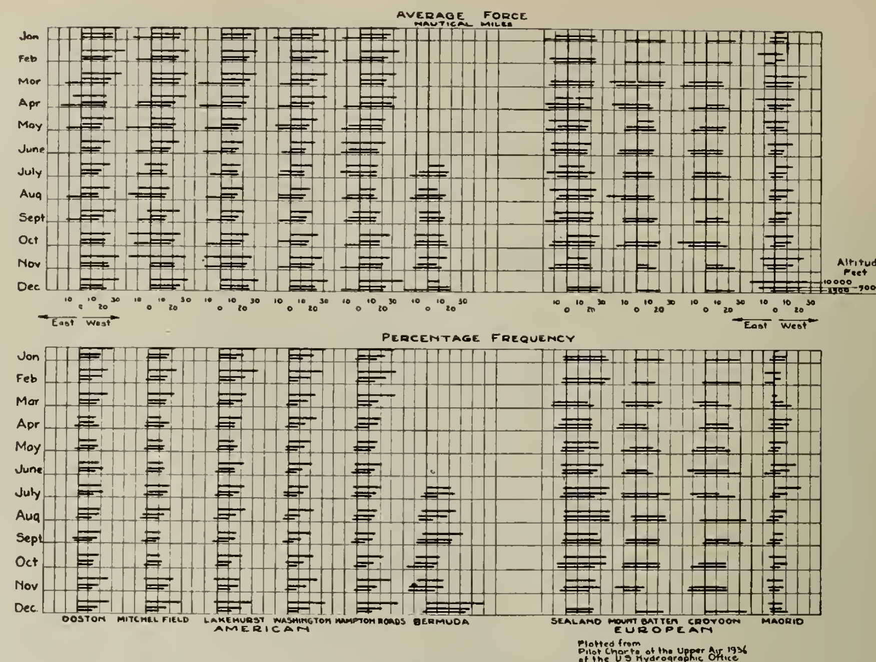


**Fig. 11—Variation of East-West Winds with Altitude.**

*Weather Information*

Reports from ships at sea on the regular steamer lanes to the south of the route and from Canadian and United States stations enable the surface weather along the direct route to be reasonably well forecast, since the weather of this area is generally "made" to the west and south. Numerous reports and hence good coverage results from the density of shipping along the New York-English Channel lanes.

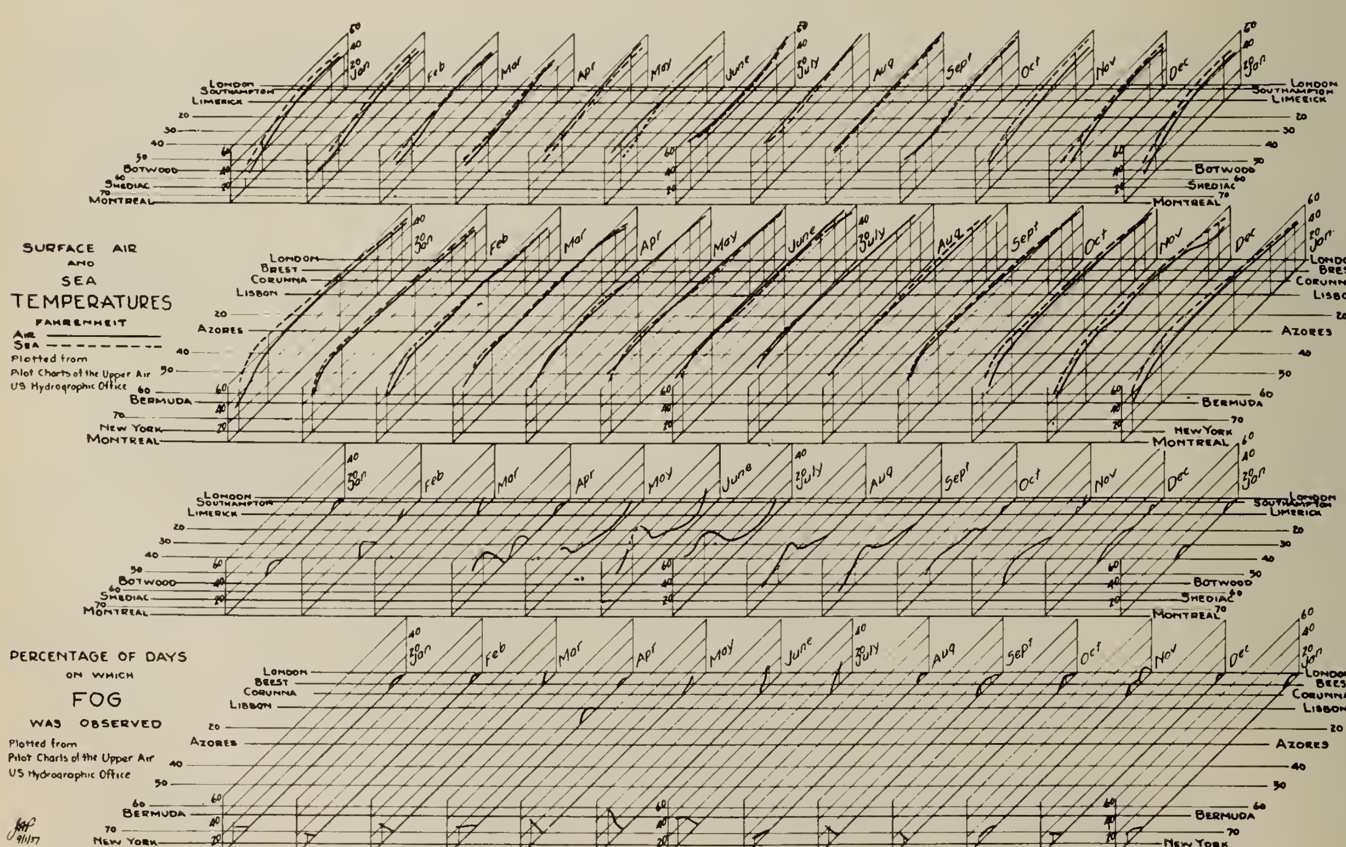


**Fig. 12—Surface Air and Sea Temperatures—Percentage Days with Fog.**

The European coast section of the southern route, the section between the European coast and the Azores, and that between Bermuda and the coast of the United States are satisfactorily served by reports from ships. There is little shipping, however, between Bermuda and the Azores and still less south of this line and it is in this region that the tropical cyclones originate. Forecasting for this section, nearly 50 per cent of the whole route, is therefore unsatisfactory.

*Summary*

On the whole, it is concluded from the foregoing that the southern route, from a weather standpoint, possesses but slight superiority over the direct route. Because of the improvement in blind flying and landing equipment, services and technique, lack of visibility due to fog and cloud is no longer a serious handicap and blind flying is inevitable in the operation of a regular and frequent service. It is not improbable that, in the near future, if not now, fog will be of less menace to aircraft than to ships. Also, the real meteorological hazard, that due to the formation of atmospheric ice, while it may be found to be more frequent on the direct route, has already been encountered in the south.

### Terrain

The southern route is based on the Azores and Bermuda, the former about 850 miles off Portugal and the latter nearly 700 miles from the North American coast.

The Azores, or Western Isles, belonging to Portugal, are (see Fig. 13) a scattered archipelago of some nine small mountainous islands which rise sharply from their scree covered shores. The volcanic peak of Pico, rising to 7,821 feet, is the highest. There is said to be no suitable base for flying boats in the islands. Of the three principal ports, Angra, Ponta Delgada and Horta, the latter is the only one worth considering for aircraft and its effective size is smaller than charts indicate, due to silting.[16] While adequate for ordinary landings, a long take-off run would extend out into the open sea. Considerable expenditure would be necessary to make it a good harbour. Some dredging was

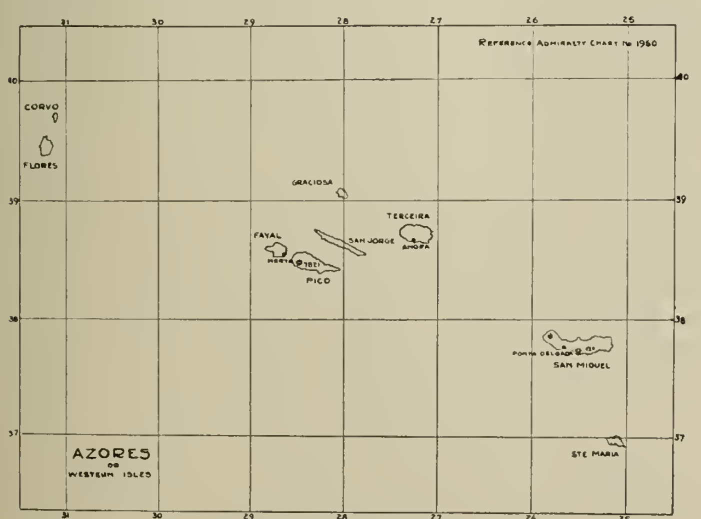


**Fig. 13—The Azores.**

recently done. The inland lakes, surrounded by mountains, are unsuitable for use by large flying boats. The largest lake, Sete Cidades, on San Miguel, the crater of an extinct volcano, is some 10 miles in circumference, and of irregular shape. There is a small landing field on a plateau on the island of Terceira and it was recently reported that the

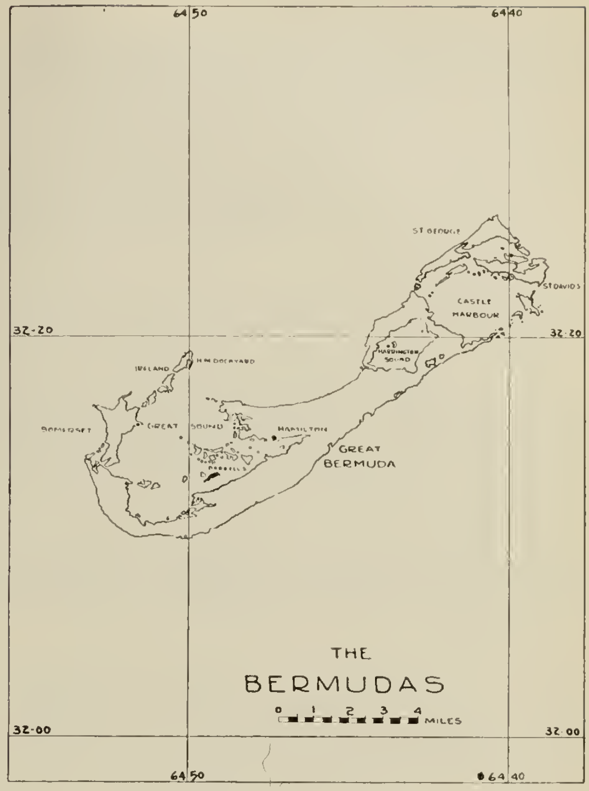


**Fig. 14—The Bermudas.**

French had selected this site as capable of enlargement, at small cost, into an aerodrome for a transatlantic service.

Because of their exposed position, winds from the W. and SW. render navigation dangerous about the islands. Intense squalls in the vicinity frequently cause tide races, the "houle," to sweep about the islands. Under these circumstances, in spite of the fact that the sea is quite calm during part of the year, lacking harbours, the alighting and take-off of large seaplanes would often be hazardous and regularity of services difficult to maintain.

The Bermudas (Fig. 14) comprise a compact group of some 150 sandstone and coral islands, mostly small islets, on a submarine bank and surrounded by a reef of coral covered sandstone. The sandstone of the islands forms irregular hills, some 200 to 250 ft. in height. The group is some 15 miles long and 5 miles in extreme width and encloses several large and well protected harbours. Darrell's island in the Great Sound is being equipped as a base for a Bermuda-New York air service.

The Bermudas are a British possession and the site of a naval station.

In Europe, the southern route, using the stages London-Brest-Corunna-Lisbon involves landings in French, Spanish, and Portuguese territory and, in America, a landing in and flight over United States territory.

The direct route will use bases in Ireland and Newfoundland. Among the many fine natural harbours of Ireland, there are several well suited for air bases. The north and west coasts are high and rocky—those of the east and south less so. The more mountainous areas are in the north and south and the central plain extends, in places, to the east and west coasts.

Promising sites for combined sea and land bases appear to include (see Fig. 15), on the north coast, Lough Foyle, near Londonderry (used by the Italian flight in 1933), on the west coast, Galway Bay and the estuary of the Shannon, and Cork Harbour on the south coast.

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[16]The Lockheed Sirius of Colonel Lindbergh was unable to take off here, fully loaded, in November 1933. It was used by the Italian flight on the return from Chicago in the same year.

There are high hills (2,000 ft.) west of Lough Foyle. Between Galway Bay and the Shannon estuary, the country is relatively low, few peaks exceeding 1,000 ft. and there is a large percentage of low land. The excellence of Cork Harbour is well known. There is much sheltered water in the reaches of the harbour and many sites suitable for the construction of airports. The surrounding country is low, but the highest hills in Ireland (3,500 ft.) lie between Cork and the west coast. As indicated in the previous paper already referred to, Galway Bay and the Shannon estuary appear most suitable.

The rugged and rocky coast of Newfoundland, with high and perpendicular cliffs in most places and deep water to the edges, is heavily indented (see Fig. 5). There are many large bays and numerous islands, especially on the east and south coasts. The hills are mainly near the coasts and average 1,500 ft. in height. The highest mountains are in a range extending some 200 miles along the northwest coast and rise to over 2,200 ft. almost directly from the sea.

The interior is mainly undulating, much of it heavily wooded, in which there are innumerable lakes and rivers.

In view of the foregoing, it should not be as difficult, as is often assumed, to find ice and fog free harbours suitable for marine bases, or quite satisfactory airport sites in the interior.

From the standpoint of intermediate bases, the southern route is handicapped by the conditions in the Azores, on which the route is dependent, while in Ireland and Newfoundland, on the other hand, there are numerous suitable sites for intermediate bases for the direct route.

### The Better Route

It is concluded from the foregoing brief comparison of the two routes on a basis of length, weather and terrain, that, while some advantage rests with the southern route from the standpoint of weather, the advantage is insufficient to compensate for its much greater overall length, the greater length of oversea flight and the difficulty respecting provision of a suitable base in the Azores and hence, on the whole, the direct route is the better.


**Fig. 15—Ireland.**

It has been suggested that the direct route should be used in summer and the southern route in winter. Admittedly, the climatic conditions are, in some respects, more severe over the former in winter, but here again the decision is the fundamental one as between weather and length and terrain. In the author's opinion, the direct route is superior, even for winter operation.

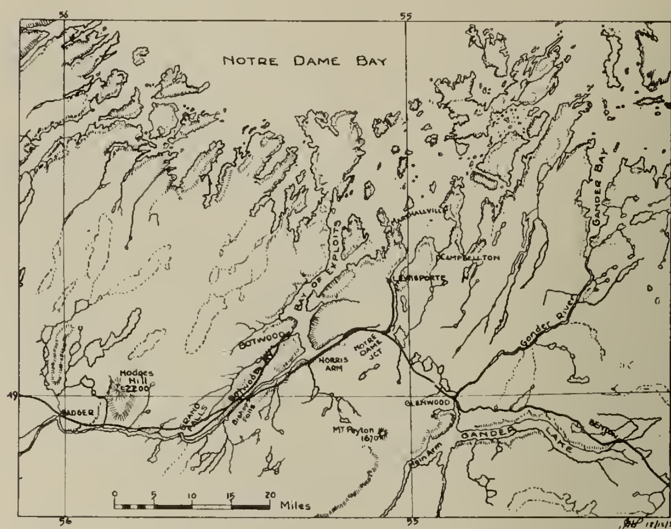



**Fig. 16—Botwood and Vicinity.**

The trans-atlantic service between London and Montreal will be an important part of the network of airlines connecting the various units of the British Empire and, as part of the Empire network, the desirability that the service should be "all-red" is obvious.

## ORGANIZATION OF THE DIRECT ROUTE

### Selection of Intermediate Refueling Bases

Until experience has indicated the most suitable type of aircraft for the service, provision should be made for both landplanes and seaplanes at the terminals and intermediate stations. There is also the possibility that aircraft of both types may continue to be used in the service.

The selection of the particular route to be followed, within the zone of the great circle and of the intermediate stations between terminals, is governed by many factors. Initially, to shorten as much as possible the oversea flight, refueling stations should be established as near as practicable to the west coast of Ireland and east coast of Newfoundland. Nature of terrain, such as adequate area of level ground, sufficient expanse of ice-free sheltered water, low-lying surrounding country, together with the usual requirements as to nature of soil, drainage, access (railroad facilities) must be considered.

Careful consideration has also to be given to meteorological conditions and, from this point of view, fog and ice conditions are important. Ice-free water is necessary for year-round operation of seaplanes and, in Newfoundland, this probably eliminates the use of lakes in the interior.

The relation of the proposed route to existing or projected air services and to other transportation systems must receive attention.

It is obvious that the particular route and sites of stations can only be decided upon after detailed information concerning these various factors has been secured and studied and with full knowledge of the relative importance of the different economic and political considerations involved.

As previously indicated, the reported route of the service planned for inauguration in 1937 is London-Southampton - (Portsmouth) - Limerick - Botwood - Shediac(?) - Montreal.

Portsmouth is contemplated as the marine terminus of the main Empire Air Routes. Temporarily, Hythe or Southampton Water, where slipway and hangar facilities exist, is in use (December, 1936) as a flying boat base for the India service and will be used for the Atlantic service. Langstone Harbour, adjacent to Portsmouth, will probably be made the permanent base. It is said to be fog-free and, by means of barrages across the entrance, or by dredging channels, an excellent marine base can be provided and there are suitable areas available for an aerodrome. A railroad runs close by and the site is close to Southampton, with its many facilities and rail connections to London.

The site of the combined marine and land base, to be named Kilconry, reported being prepared in Ireland, is at Rynanna Point, in County Clare, at the junction of the River Fergus with the Shannon, about halfway between Limerick and the coast. The Shannon is here some eight miles wide and the surrounding land is flat. A temporary base will be at Foynes, County Limerick, on the south shore of the Shannon and permanent wireless stations will be located in the village and on Foynes island in the river.

In Newfoundland, based on the results of special meteorological investigations, both surface and upper air, carried on since 1934, two sites have been selected and are in preparation. Port Botwood, a port near the mouth of the Exploits river (see Fig. 16), chosen as the marine base, is now used for the shipment of pulp and paper and is connected by a branch railroad with the mills at Grand Falls and the main line of the narrow gauge Newfoundland railroad. The river at Botwood is about a mile wide and the harbour is reported to be fog-free and satisfactory for flying boats.[17]

As the topography of the surrounding country is not suitable for the construction of an aerodrome, the site selected for the Newfoundland airport is at Hatties Camp, north of Gander Lake and south of the railroad, some 42 miles east of Botwood and about 30 miles from the east coast where an ample area is available, requiring little levelling and with good drainage. The elevation is 500 ft. above sea level. Clearing and grading started in 1936. Four concrete and tar macadam runways, intersecting at 45 deg., are to be constructed, each 1,500 by 200 yd., and with a load capacity of 5 tons per sq. ft. The main runway, equipped for blind landings, runs NE.-SW. and is to be 1,600 by 400 yd.

In Canada, there are several possible sites for the terminal of the route from Newfoundland, including Shediac, Moncton and Saint John in New Brunswick and Sydney or Louisburg in Nova Scotia. Although no decision will likely be made until after trial flights, Shediac appears to be the preferable site. It possesses adequate facilities for manoeuvering large flying boats and is close to Moncton (which lacks such facilities), on the trans-Canada airway. Shediac was used by the Italian flight in 1933.

### The Fuel Load Handicap in Long Range Flight

Unlike other means of transport, the engines of heavier-than-air aircraft must not only supply the power for propulsion, but also for the support of the aircraft and its load. In consequence, the horsepower required and the fuel consumption are higher for a given payload than for transport in which the weight is supported directly by the earth or by displacement.

The limitation imposed on the payload by the large load of fuel that must be carried for the transatlantic flight is illustrated by the figures of Table III derived from a simple approximate calculation. The magnitute of the necessary fuel load, the possible payload (neglecting weight of crew, etc.) and the influence thereon of structural weight, power loading and cruising speed are shown.

Table III

Payload Capacity

Assumptions:—Distance 1,800 miles, 30 m.p.h., head wind, cruising power 2/3 rated power, cruising fuel consumption 0.6 lb. per hp. per hr.
*W* = gross weight of aircraft.

| | Weight ratio*—1.75 | | | Weight ratio*—2.00 | | | Weight ratio*—2.25 | | |
|---|---|---|---|---|---|---|---|---|---|
| Power loading†.... | 10 | 15 | 20 | 10 | 15 | 20 | 10 | 15 | 20 |
| **Range—Hours** | | | | | | | | | |
| | 10.7 | 16.1 | 21.4 | 12.5 | 19.0 | 25.0 | 14.0 | 21.0 | 28.0 |
| **Fuel Load** | | | | | | | | | |
| Cruising speed m.p.h.—120 | 0.80*W* | 0.53*W* | 0.40*W* | 0.80*W* | 0.53*W* | 0.40*W* | 0.80*W* | 0.53*W* | 0.40*W* |
| 150 | 0.60*W* | 0.40*W* | 0 30*W* | 0.60*W* | 0.40*W* | 0.30*W* | 0.80*W* | 0.40*W* | 0.30*W* |
| 180 | 0.48*W* | 0.32*W* | 0.24*W* | 0.48*W* | 0.32*W* | 0.24*W* | 0.48*W* | 0.32*W* | 0.24*W* |
| **Pay Load Carried—Pounds** | | | | | | | | | |
| 120 | 0 | 0 | 0.03*W* | 0 | 0 | 0.10*W* | 0 | 0.02*W* | 0.15*W* |
| 150 | 0 | 0.03*W* | 0.13*W* | 0 | 0.10*W* | 0.20*W* | 0 | 0.15*W* | 0.25*W* |
| 180 | 0 | 0.11*W* | 0.19*W* | 0.02*W* | 0.18*W* | 0.26*W* | 0.07*W* | 0.24*W* | 0.32*W* |
| **Pay Load Carried—Pounds per Horsepower** | | | | | | | | | |
| 120 | 0 | ·0 | 0.6 | 0 | 0 | 2.0 | 0 | 0.3 | 3.1 |
| 150 | 0 | 0.5 | 2.5 | 0 | 1.5 | 4.0 | 0 | 2.3 | 5.1 |
| 180 | 0 | 1.7 | 3.8 | 0.2 | 2.7 | 5.2 | 0.7 | 3.6 | 6.4 |

$$\text{*Weight ratio} = \frac{\text{gross weight}}{\text{net weight}} \qquad \text{†Power loading} = \frac{\text{gross weight}}{\text{total rated power}}$$

With an aircraft of normal design, in which, for a long non-stop flight, the weight of fuel leaves a very small part of the disposable load available for pay load, the desired pay load capacity can be attained, within certain limits, by increasing the size of the aircraft until the fraction of the disposable load available equals the desired pay load. This procedure is obviously uneconomical. The alternatives are mid-ocean refueling, fueling in the air or a resort to some form of assisted launching.

### Mid-Ocean Refueling

Evidently, if satisfactory refueling facilities could be provided at one or more points in mid-ocean, the fuel load carried could be reduced and the pay load correspondingly increased. Two alternative proposals for mid-ocean refueling have been made, one by the use of ships and the other by the provision of floating islands.

The Deutsche Luft Hansa has employed "depot ships" on the South Atlantic section of its air mail service to South America since 1934 and in the summer of 1936 employed one of these ships in trial flights across the North Atlantic by way of the Azores.

The depot ships of the D.L.H.[18] are each equipped with a compressed air catapult for launching flying boats, a rotating and folding electric crane for lifting the aircraft on board or on the catapult and a trailing apron or "stau-segel" for facilitating the hoisting of aircraft on board in rough weather. The ships also have very complete radio and meteorological equipment.

The depot ship was originally employed as a refueling station in mid-ocean. More recently, having improved the range of the aircraft, the ships have been used for launching the aircraft at each end of the oversea stage. As a refueling station, the aircraft flew to the ship, alighted on the sea,

[17]Colonel Lindbergh refueled his Lockheed Sirius here in 1933.

[18]Details of the depot ships and of the South Atlantic service are given in Appendix VII.

was hoisted aboard, refueled and serviced and launched by catapult for the second stage of the crossing.

The depot ship is mobile, permitting the route to be changed at will, as, for instance, from the direct in summer to the southern in winter. If the aircraft is forced down within reasonable distance (and in fair weather), the ship can proceed to its assistance. The cost of the ship is low, as compared with that of a floating island.

However, as a permanent refueling station, in mid-ocean on a schedule service by the direct route, the depot ship is considered impracticable because of the frequency of gales on the North Atlantic which would render disastrous the alighting of aircraft on the sea.

On the other hand, as a temporary expedient during the initial operation of the service, to serve as a beacon ship and meteorological station, the depot ship possesses attractive possibilities.

Floating islands to serve as refueling stations in mid-ocean have been projected from time to time. Most such schemes were, to use M. Bleriot's description "a little fantastic."

The design to which most careful study and tests have been devoted and which appears the most promising technically is the so-called Armstrong Seadrome, as described in Appendix VIII.

The seadrome is a floating structure, embodying an unobstructed flying deck, with hangar, shop, radio and meteorological facilities and accommodation for crew and passengers. Its design is such that it is claimed to be unaffected by wave action. It is retained in place by special anchoring arrangements.

To provide a flight deck of adequate size for modern high speed, heavily loaded aircraft, the structure must be large and, while possibly technically feasible, the cost will be high and the financial burden on the service excessive.

From the point of view of the direct route, the fundamental obstacle to the use of the seadrome is, that owing to the surface climatic conditions—gales and fog—landing on the restricted deck would be hazardous and often impossible.

It is concluded that the provision of mid-ocean refueling stations on the direct transatlantic route is impracticable.

### Fueling in Flight after Take-Off

By having the aircraft take off and climb to its operational height, without its fuel load, and there supplied from another aircraft with the fuel for the journey, the take-off handicap would be overcome.

Many tests of methods of fueling in flight have been made and endurance records have been established by means of numerous refuelings in the air. The operation is, however, one that so far has only been performed in fair weather. In its present stage of development, it is not considered suitable for use in a regular commercial service, the schedule of which must be maintained irrespective of weather conditions.

### Take-Off Conditions

The take-off speed and the landing speed may be taken as roughly equal to the stalling speed of the complete aircraft. The latter depends on the maximum lift coefficient of the wing, the air density (altitude of the landing point) and the wing loading. The maximum lift coefficient may be increased by such lift increasing devices as slots and flaps and with good control at low speeds, the landing speed, and to a less extent, the take-off speed, can be correspondingly decreased.

Actual take-off speeds may be 10 per cent higher than minimum flying speeds, to provide a reserve of lift at take-off. At the same time, "ground effect" reduces the landing and take-off speeds.

The power required for take-off is greater than for normal flight. For take-off under full load, in a reasonable distance or time, the maximum permissible take-off power of the engines is usually employed, while for cruising in level flight the engines are throttled to cruising power for which the fuel consumption is a minimum. As the maximum take-off power of the engines may be 110-125 per cent and the cruising power about 66⅔ to 75 per cent of rated power, it is evident that the power used for take-off is about twice that for cruising.

With an unlimited take-off run or time, the take-off power would of course be less.

Additional power over that for cruising is also required for climbing, but this need not be large if there are no high obstacles to be cleared in the vicinity of the stations.

A further consideration is that a margin of power over that required for cruising is necessary to enable the aircraft to remain in flight in the event of failure of one or more engines and to permit the engines to operate at reduced power for low fuel consumption and wear on engine.

The approximate analyses of take-off conditions given in Appendix IX indicates, in a general way, the factors affecting take-off and their relative importance.

### Assisted Launching

With assisted launching, by catapult or otherwise, the aircraft for a given long range service will be smaller and of lower power since it can be designed specifically for cruising conditions with very high wing loading and a cruising speed approximating that for maximum aerodynamic efficiency. It is seen, for instance, from the graphs of Fig. 24, that, for a cruising speed of say 160 m.p.h., the pounds of gross weight carried per horsepower at different wing loadings are as follows:

| | | | |
|---|---|---|---|
| Wing loading | 18 | 28.6 | 40 |
| Pounds per horsepower | 15.0 | 21.1 | 26.5 |

The saving in power and consequent fuel consumption thus affected can be used to increase the payload, the range, or both together, or the original power can be used to carry the same load at a higher speed. In this way, long range and large payload can be combined in the same aircraft.

Assisted launching of heavily loaded aircraft is subject to the condition that a large part of the load must be of a consumable or readily dischargeable nature, in order that the landing speed at the end of the flight may not be excessive and that, in an emergency, a safe landing may be made by jettisoning part of the load.

Even with normal aircraft of high wing loading, able to take off unassisted under prescribed airworthiness requirements, the landing speed may exceed safe limits and require jettisoning of fuel if an emergency develops immediately after take-off.[19] For this reason, one noted designer of flying boats has proposed that aircraft should be licensed for a higher load for take-off than for landing.

In the case of marine aircraft, the displacement of the flotation gear will be that required for conditions at the end of the flight and the hull or floats can therefore be smaller, weigh less and have less drag than that necessary for unassisted take-off.

### Catapulting

The launching of aircraft by catapulting is of course not new, since a simple device of this kind was used by the Wright brothers and the system employed in launching gliders is of the same kind.

Naval vessels have long been equipped with aircraft catapults and, as already mentioned, catapults have been employed on liners for launching aircraft in connection with ship-shore air mail services.

It is indicated in Appendix VII that the catapult equipped Deutsche Luft Hansa depot ships now function

[19]Such a situation has occurred on at least one occasion in the case of an aircraft of the type on which the curves of Fig. 24 were based.

as launching stations in the South Atlantic service. From the German standpoint, lacking shore bases, the mobility of the ship is an important consideration. For the operation of a North Atlantic service over the direct route in summer and the southern route in winter, this mobility would also be advantageous, obviating the necessity of duplicate shore launching stations. Further, the use of the depot ship would satisfactorily overcome many of the difficulties arising from conditions in the Azores. But, with a permanent route and fixed stations, the mobility of the depot ship is not necessary.

However, the many catapult launchings that have been made on the D.L.H. South American service without an accident, insofar as is known, do prove that this method of launching heavily loaded aircraft can be safe, reliable and generally satisfactory on a transoceanic air mail service.

The launching of commercial aircraft by means of long run catapults of the car and track type was suggested to the author by Mr. D. S. Atkinson, in January 1935. Similar suggestions have since appeared in the technical press and it is reported that the use of catapults is receiving consideration for the transatlantic service planned for 1937.

The proposal, which is dealt with in some detail in Appendix X, is briefly as follows. The launching runway is a length of track about one-half mile long, laid on land in the direction of the prevailing wind. If for marine aircraft, the track is laid on or near the shore. The car is driven by cable from a fixed prime mover, Diesel or gasoline engines on the car, or by aircraft engines and airscrews. The aircraft cradle is so arranged as to permit the aircraft to align itself with the relative wind. The attachment of the aircraft to the cradle is such that, on attaining a speed in excess of the minimum flying speed, acceleration is reduced to zero and the car speed held constant until the pilot signals and releases the lock. The car then begins to decelerate and the aircraft flies off. After the launch, the car is brought to a stop under the control of the operator.

*Launching from an Aircraft in Flight*

Many years ago, a glider was dropped from a balloon[20] and more recently aeroplanes have been launched from rigid dirigibles. At the present time, two aircraft are nearing completion which are intended to be used in combination, one being launched from the other.

In this so-called composite aircraft, proposed by Major R. H. Mayo, the two aircraft combined function as a single unit for the take-off and later, at altitude, the one serves virtually as a catapult for launching the other. While the detailed arrangement may be varied to suit different conditions, in the composite aircraft under construction, the upper component to be launched is a high performance, heavily loaded seaplane, mounted on top of the lower component or carrier aircraft, a lightly loaded flying boat of more or less normal design. Locked together, the characteristics of the combination are such that the stalling speed is low and a satisfactory take-off, together with good climb, are possible.

The patents associated with the proposal cover principally the method of effecting separation of the components through the medium of aerodynamic forces. Apparently the aerodynamic characteristics of the wings of the two components differ, due either to a use of different basic sections or to the use of slots and flaps and are so chosen as to ensure the upper component carrying a larger and larger share of the combined weight as the speed increases until at launching speed the upper component is lifting more than its own weight so that when released the two components separate. It is understood that the patents also cover separation through the increasing of the incidence of the upper component during flight.

Apparently during take-off all control rests with the pilot of the lower component, the controls of the upper component being locked in neutral and the pilot virtually a passenger. On reaching the proper height, reported to be 10,000 ft., the aircraft levels off and accelerates to a speed well above the stalling speed of the upper component. At this speed (over 100 m.p.h.) the lower pilot signals his colleague, releases one part of a dual device locking the components together and relinquishes control. The upper pilot assumes control, releases a second part of the locking device and, on the machine reaching a speed corresponding to a predetermined separating force, the locking device automatically releases and permits the components to separate.

After the launch, the service aircraft proceeds on its flight and the carrier returns to its base.

It is obvious that the safety of the launch will depend on excellent co-ordination of controls and infallible working of the locking device and severance of all connections on separation. Further, the stability of the composite aircraft on the water, taking-off and in flight, and of the components during separation will require careful study.

The few constructional and performance particulars of the composite aircraft so far made public, are listed in Appendix XI.

*The Composite Aircraft vs Catapult Launching*

As compared with the fixed catapult, the following advantages have been claimed for the composite aircraft:

1. *Lower Cost*—The lower component now under construction is reported to be a four-engine boat similar to the Empire boats. While its cost is not known, it is probably not less than the reported cost of the Sikorsky S-42 flying boats, namely $250,000, and a conservative estimate of the cost of the lower component would be $150,000. It is difficult to conceive of a mile long track and launching car and necessary land costing this much.

   The cost of the upper component will be little, if any less, than that of the similar aircraft for catapult launching.

2. *Greater Mobility*—For operation of an air service over a permanent route with fixed bases, mobility is of no advantage.

   For military and naval use, mobility would be distinctly advantageous.

3. *Elimination of Risk Attendant on Launching at Low Height*—Admittedly, this hazard is present with catapult launching, but its magnitude has been exaggerated. With multi-engined aircraft, the danger of all engines cutting out, particularly immediately after launching, when they are presumably in the best of condition, is remote. As indicated in Fig. 28, an aircraft is easily capable of maintaining level flight and climb with a wing loading 40 per cent greater than normal on three out of four engines operating at 75 per cent power.

   With a car and track launching gear, the catapulting speed can be made considerably higher than the stalling speed of the aircraft and, if the latter is held to the car until this speed, on release it will immediately climb.

   Also, the Deutsche Luft Hansa has proved, in three years of regular use on the South Atlantic under much more difficult conditions than those which will obtain in a long-run fixed catapult, that launching by catapult is safe and reliable in commercial service. It remains to be seen whether the separation of the components of the composite aircraft can be as safely effected in flight and at high altitudes.

[20]Montgomery glider dropped from hot air balloon at 4,000 ft. in California, April 1905.

4. *Permits the Use of Fixed Pitch Airscrews*—For unassisted take-off of aircraft with high wing loading and fully supercharged engines, variable pitch airscrews are essential. With the composite aircraft, the heavily loaded upper component, being relieved of most of the burden of take-off, can be fitted with a fixed pitch airscrew, designed for cruising condition, with less sacrifice of efficiency during take-off. There is therefore a saving in weight and cost.
5. *The Aircraft can be Launched at Higher Speed*—A long-run catapult of the type mentioned can launch an aircraft at quite as high a speed for the same expenditure of effort. For the land catapult considered in Appendix X, the maximum power for the car is seen to be from 2,000 to 3,500 hp. for launching a 25-ton aircraft at 100 m.p.h., compared with a reported power of about 3,500 hp. for the carrier component of the composite aircraft to launch a much lighter aircraft at the same speed.
6. *Reduced Cost of Operation and Maintenance*—It is difficult to see wherein these costs will be less than for a long-run catapult. The same handling will be involved in placing the service aeroplane on the car or carrier aircraft and the cost of operation of the carrier may easily exceed that of the car. The economy of the two service aircraft should not be greatly different if a low rate of climb is permissible for the catapult aircraft. In the case of a marine carrier component, depreciation and maintenance will likely be higher than for the catapult.
7. *Ability to Use Small Aerodromes and Harbours*—It is considered that, in this respect, the advantage would rest with the catapult rather than with the composite aircraft. In any case, for operation over a permanent route, such as the one under consideration, with well selected bases, there should be no necessity to use unduly restricted take-off areas.
8. *Ease of Take-Off—Permits Night Take-Off with Safety*—This advantage applies with equal, if not greater force, to catapult launching, since, with the latter, the car runs on fixed rails and launching from a car should be easier than from another aircraft in flight.

   Blind take-off, under condition of poor visibility, in fog or rain or at night, is part of the regular routine in the D.L.H. service using catapults. Such take-off should therefore be relatively simple and straightforward with larger shore catapults.

   It is clear from the foregoing that the assisted launching of aircraft by means of the composite aircraft possesses, for commercial operation over a permanent route, only the one advantage—that of launching at height—and that this advantage is offset by advantages possessed by the fixed long-run land catapult.

   The economic advantages to be derived therefrom justify the provision of equipment for launching aircraft on the transatlantic service and, from the foregoing, it is concluded that the most promising means of launching is the fixed long-run shore catapult.

### Meteorological Service

An efficient meteorological service for the collection of weather reports and the preparation of forecasts is one of the most vital elements of the ground organization of a transatlantic route.

The service should be equipped and organized to provide the pilot at take-off with a detailed weather forecast for the flight. This forecast should be as complete as possible, not only with respect to surface conditions, but also, insofar as existing knowledge permits, with respect to upper air conditions.

It is reported that the meteorological work on the western side of the Atlantic, for the proposed air service, was undertaken by Canada in 1935 and that the organization of the work is now actively proceeding.

The forecasts of the Meteorological Service of Canada[21] are prepared twice daily, at 8.00 a.m. and p.m., on weather reports received from some 69 Canadian stations and from 159 in the United States. Reports are also received from 4 stations in Greenland and one in Bermuda, together with about 25 daily reports from Europe. An average of 12 to 16 reports are received from ships on the Atlantic, of which 5 or 6 are between Ireland and Newfoundland.

Recently 2.00 p.m. observations have been received from 34 stations in Canada, 135 in the United States and 6 in Newfoundland, for the preparation of 2.00 p.m. weather maps which are used to correct forecasts.

For adequate forecasting for the transatlantic air service, observation and reporting facilities should be increased in the region between Newfoundland and Bermuda and additional facilities provided in the Ungava peninsula, northern Ontario and the Canadian Northwest. Weather observations are now made in these regions from Dawson, Mayo, Aklavik, Fort Norman, Simpson, Smith, McMurray, Coppermine, Chesterfield Inlet, Nottingham island, Cape Hope's Advance, Resolution Island, Churchill, Moosonee, Chibougamau and Cartwright.

It is essential that the number of upper air observations be increased. At the present time, such observations by balloon are made only at Sable island, Fredericton, Clarke City, Dolbeau, Moosonee, Toronto (also by aircraft, to 10-12,000 ft.), Winnipeg, Vancouver and Victoria. Reports of aeroplane observations are received daily from a maximum of 22 upper air stations and of pilot balloon observations from 50 stations, in the United States.

Regular aviation forecasts by the Canadian service are now confined to those for the Montreal-Rimouski, Montreal-Albany, Montreal-Ottawa and the north shore of the St. Lawrence, Rimouski-Harrington Harbour services and for the Rouyn area. Pilots on the Montreal-Rimouski service report in detail the weather encountered.

With the inauguration of the trans-Canada air service in the near future, an extensive and frequent aviation forecasting service will necessarily be organized which will be exceedingly useful in connection with the transatlantic service.

Additional weather reporting facilities, particularly respecting upper air conditions, will be required at the European end of the route. A special forecasting station is being established at the Foynes base in Ireland.

There is a fully equipped meteorological station and forecasting centre at Bermuda at which pilot balloon observations are regularly made. It is being prepared for service in connection with Atlantic air routes.

Since 1934, upper air conditions over Newfoundland and the Gulf of St. Lawrence have been studied at meteorological stations and by means of aircraft. There are now operating, nine stations in Newfoundland. Pilot balloon observations are made from two of these and aeroplane observations at one station. A preliminary analysis of records extending over ten years to determine wind speed and direction was completed in 1936.

Upper air observations should be made, if feasible, by balloon, from transatlantic steamers, preliminary to the establishment of the air service and possibly during the operation of the service. However, knowledge of upper air conditions over the Atlantic will be built up principally on the reports of the crews of aircraft operating the service, when established.

[21]Information kindly furnished by the Director.

A comprehensive weather forecasting system is being arranged, to include the establishment of an extensive network of stations in Newfoundland, for furnishing information to a central forecasting station at Botwood, provision for the training of forecasting personnel and the study of the meteorological problems connected with the operation of the transatlantic service.

With a flight weather forecast, complete in every possible detail, based on the latest weather analysis and using modern forecasting methods, furnished immediately prior to each flight, and with aircraft having a reasonable margin of range over the minimum, rigid adherence to the great circle course will be unnecessary, and the most favourable course and flying levels can be used as was done by Costes and Bellonte on their westward flight and as is being done on the Pacific flights. Not only should the best course and levels to take advantage of favourable and avoid unfavourable winds be worked out in advance, but also all other possible flight details based thereon, such as cruising speeds, engine operation, times, etc.

### Radio Service

The importance of adequate radio services in connection with the operation of a transatlantic air service is obvious. Every effort should be made to provide the most up-to-date and dependable equipment. In addition to equipment of proved efficiency and reliability, provision should be made for service trials of promising new developments.

The function of the radio service will be threefold, namely as a means of communication, as an aid to navigation and as a guide in blind landing.

Two-way communication between aircraft and the route terminals, shore stations and ships at sea is necessary to permit the pilot to secure flight information as to weather ahead and airport conditions, to report his progress and position and weather encountered and to call for help in an emergency.

For this service, there should be provided both short and medium wave equipment for two-way communication, by voice and key, to ensure absolute dependability under all conditions.

Ordinary two-way communication over water, with aircraft equipment is now practicable over distances of 3,000 miles and is possible under certain conditions up to nearly 4,000 miles.

For navigation across the Atlantic and between stations, radio at present will be relied upon primarily to check and supplement navigation by the well tried and proved methods based on celestial observations and dead reckoning, using such new and improved instruments as have been developed for aircraft use.

Radio direction-finding equipment has proved quite accurate, even over long distances, in flight over the South Atlantic and Pacific and indeed it must be largely relied upon for navigation under conditions of poor visibility. For the determining or checking of position and course, dependence will be placed principally on fixes obtained from shore D.F. stations, verified by bearings taken, using direction-finding equipment in the aircraft, on shore stations, steamers or even broadcasting stations.

Long range aviation D.F. equipment now in service is capable of determining bearings within 1° at 250 miles or less and within 3° at ranges from 1,200 to 1,600 miles, at frequencies from 6,000 to 250 kilocycles, and bearings have been obtained at a range of over 2,000 miles. The equipment is relatively free from night effect. A rotatable (and retractable) loop is of course used to permit the taking of bearings without deviating from the course and to permit "homing." Indications are both aural and visual.

While bearings determined at shore D.F. stations are more accurate and will normally be depended upon for fixes, bearings determined with the direction-finding equipment in the aircraft will be found useful and convenient and will doubtless be regularly employed as a matter of routine.

The pilots of the D.L.H. South Atlantic service rely almost wholly on their own bearings taken on the depot ships and shore stations, using medium wave, although the bearings are compared with those obtained by the depot ships.

For the direct transatlantic route to be inaugurated in 1937, large up-to-date D.F. stations are being erected at Foynes, County Limerick and at Ballygirreen, County Clare, in Ireland and at Botwood, Newfoundland. Doubtless other D.F. stations will be provided in Newfoundland and possibly some of the numerous marine D.F. stations of the Department of Transport, along the Atlantic coast and Gulf of St. Lawrence, will be equipped to serve as D.F. stations for the transatlantic service.

Guidance in blind landing is the third duty of radio in the operation of a scheduled commercial air service. The aircraft, having been navigated by means of one or all of the three available methods to within 100-200 miles of the terminal, then picks up the beam from a radio beacon and follows it in. When 10-15 miles from the beacon, the ultra short wave (about 9 m.) fan-shaped landing beam is picked up and followed, passing, at between 1 and 2 miles from the landing area and at about 2,000 ft. altitude, the vertical conical beam of the first marker beacon. Following the curved lower fringe of the landing beam, the second marker beam is passed about 300 yards from the boundary. Continuing to follow the fringe of the beam, the aircraft is brought within a few feet of and parallel to the surface. By slowly throttling and easing back on the control, the aircraft is put down. Both visual and aural indication is provided.

Insofar as is known, blind landing equipment of this kind has not been used over water. The difficulties involved appear to be mechanical since there is nothing to interfere with the electrical principles involved. The fixing of the small transmitters for the beams and markers, to prevent their disturbance by wave action, to allow for tides and so that they may be out of the way presents difficulties.

Several British, most German and many other European airports are now equipped with one or other of the several types of blind landing equipment, now perfected, and blind landings are made as a matter of routine.

Needless to say, the terminals and stations of the transatlantic route should be so equipped.

In this connection, for use, both for navigation and approach to the airport, the direct reading radio compass, using a cathode ray oscillograph tube as an indicator, is very promising. This compass, invented in Canada in 1924, by Major-General A. G. L. McNaughton and Lieut.-Col. W. Arthur Steel is now undergoing development in the laboratories of the National Research Council. It has been improved by Dr. J. T. Henderson to indicate sense as well as direction of the bearing and the sensitivity of the receiver has been increased. The compass possesses a number of points of superiority, including immunity from noise and interference effects, simplicity of operation, ease of reading and the possibility of securing simultaneous bearings on two or more stations. The compass is to undergo service trials in Canada in 1937.

### AIRCRAFT

Aircraft of the heavier-than-air type differ from all other means of transport in which the weight is supported directly by the ground or through displacement, in one very important particular, namely the variation of power with economic speed. With land transport, the power increases rapidly with speed. Similarly with ships there is a limiting economic speed depending on the size and shape of the hull beyond which there is a prohibitive increase in power. On the other hand, there is for every aeroplane a most economic speed in relation to its load and any increase or decrease in this speed adversely affects the economy (see Fig. 24).

The wing characteristics are such that high efficiency is attained only over a limited range of incidence. Operating at this favourable incidence and varying the speed by variation of wing loading or altitude of flight, the power increases only as the speed.

A comparison of air transport with other means of transport is given in Table IV. The figures are approximate only but are probably sufficiently accurate for the purpose.

Table IV Comparison of Means of Transport

(*a*) Passenger

| | Number of passengers | Cost per passenger (dollars) | Weight per passenger (short tons) | Hp. per passenger | Speed (m.p.h.) |
|---|---|---|---|---|---|
| Modern de luxe liner... | Up to 3,000 | 20-25,000 | 40-50 | 80-85 | 30-33 |
| Small liner............ | 800 | 17-19,000 | 35 | 40 | 20 25 |
| Railroad train, steam.. | 400 | 4-6,000 | 0.5-2.0 | 10-20 | 50 60 |
| Railcar, I.C. engine.... | 30-50 | | 2.0 | 10 | 50-60 |
| Motorcar............ | 5 | 150 up | 0.3-0.5 | 10-20 | 30-60 |
| Airship............ | 50-72 | | 2.5-5.0 | 70-130 | 75-86 |
| Aeroplane—boat....... | 30-50 | 6-9,000 | 0.25-0.6 | 75-125 | 150-180 |
| wheeled.... | 8-10 | 5-10,000 | 0.3-0.8 | 90-180 | 180-200 |
| wheeled.... | 5-6 | 2-6,000 | 0.3-0.6 | 75-150 | 180-200 |

(*b*) Freight

| | Capacity (short tons) | Cost per short ton capacity | Weight per short ton capacity | Hp. per short ton capacity | Speed (m.p.h.) |
|---|---|---|---|---|---|
| Freighter............ | Up to 12,000 | Up to 60 | 0.5-1.5 | 0.25-0.6 | 10-18 |
| Railroad train, steam... | 1,500 | 200-250 | 0.3-0.5 | 0.3-0.5 | 30-50 |
| Truck............ | 5-10 | 1,000 | 1-3 | 2 up | 40-50 |
| Airship............ | 15-20 | | 6-10 | 180-250 | 75-85 |
| Aeroplane—boat....... | 2-8 | Up to 70,000 | 2-4 | 500-750 | 150-180 |
| wheeled.... | 1-2 | 20-25,000 | 1.5-2.5 | 200-500 | 180-200 |

## Existing Aircraft

In Tables V-VI, the reported characteristics and performances of some 70 civil aircraft, aeroplanes, flying boats, seaplanes and amphibians, have been tabulated in order of gross weight and in Figs. 17 (columns 1 and 2), and 18 are given, insofar as available, their line drawings, all to the same scale and arranged also in order of gross weight. There have been included long range, large capacity, large size, high efficiency and other aircraft, selected because of their interest in this connection.

These tables and drawings were prepared at the end of 1935. Table VII and Figs. 17 (column 3) and 19, containing particulars of certain aircraft published during 1936 were prepared early in 1937 and hence the aircraft included therein are not in proper order with respect to those of the earlier figures and tables.[22]

In column 29 of the tables is given a figure for the transport efficiency. This figure is the disposable load, in short tons, multiplied by the cruising speed in miles per hour and divided by the total rated horsepower and is therefore expressed in ton miles per hour per horsepower. It is used as a simple and reasonable measure of the value of the aircraft as a means of transport.

[22]The aircraft of Table VII and Figs. 17 (column 3) and 19, have been designated with a number and letter to indicate their relation to those of the other tables and figures.

Table V

Flying Boats, Seaplanes, Amphibians (Civil)

| No. | Aircraft: Builder, Number Name | Aircraft: Type | Engines: No | Engines: Type | Rated HP: HP | Rated HP: Height | Airscrews | Dimensions: Span | Dimensions: Length | Dimensions: Height | Dimensions: Lift'g Area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | Dornier DOX-1a | HWMB | 12 | Conqueror | 600? | - | 6tr 6pu4bl | 157·5 | 131·4 | 29·6 | 4885 |
| 2 | Latécoère 521 Lieut de Vaisseau Paris | HWMB | 6 | Hiso 12Ybrs | 800 | 13220 | 4tr 2pu 3b | 160·0 | 103·0 | 29·6 | 3554 |
| 3 | Supermarine-projected | MWMB | 6 | Buzzard | 825 | 0 | 3tr 3pu | 174·0 | 107·0 | 32·0 | 4000 |
| 4 | Latécoère 300 Croix du Sud | HWMB | 4 | Hiso | 640? | | 2tr 2pu 2b | 145 0 | 85·0 | 21·4 | 2800 |
| 5 | Glenn Martin 130 | HWMB | 4 | Twin Wasp R1830S1AG | 800 | 7000 | 4tr 3b CP | 130·0 | 90·10 | 24·7 | 2315 |
| 6 | Latécoère 30-1 | HWMB | 4 | Hiso 12Nbr | 650 | 0 | 2tr 2pu | 144·11 | 84·7 | 20·11 | 3292 |
| 7 | Bleriot 5190 Santos Dumont | HWMB | 4 | Hiso 12Nbr | 650 | 0 | 3tr 1pu 3bCP | 141·0 | 85·3 | - | 2389 |
| 8 | Liore et Olivier H-27 | MB | 4 | Hiso 12Nbr | 650 | 0 | 2tr 2pu 3b | 120·5 | 68·10 | 21·4 | 1937 |
| 9 | Sikorsky S-42 Brazilian Clipper | HWMB | 4 | Hornet 55D·16 | 700? | 3500 | 4tr. 3b CP | 114·2 | 67·8 | 17·4 | 1330 |
| 10 | Breguet Saigon | SB | 3 | Hiso 12 Ybr | 800 | · | 3tr | 115·0 | 66·8 | · | 1800 |
| 11 | Short Scipio | BB | 4 | Jupiter XFBM | 555 | 4000 | 4tr 2b | 113 0 | 78·5 | 28·0 | 2640 |
| 12 | Savoia S-66 | HWMB | 3 | Fiat A24R | 700 | - | 3pu 4b | 108·3 | 54·6 | 16·0 | 1363 |
| 13 | Short Calcutta | BB | 3 | Jupiter XIF | 495 | 0 | 3tr | 93·0 | 64·9 | 22·3 | 1825 |
| 14 | Dornier Wal 1953-34 | HWMB | 2 | BMW-VI | 500 | | 1tr 1pu 3b | 89·3 | 59·9 | 19·1 | 1220 |
| 15 | Latécoère 38-0 | HWMB | 2 | Hiso 12Nbr | 650 | 0 | 1tr 1pu 4b | 103·0 | 55·0 | 19·9 | 1400 |
| 16 | Latécoère 50-0 | HWMB | 3 | Hiso 12Jb | 400 | - | 2tr 1pu | 103·0 | 58·2 | 16·3 | 1378 |
| 17 | Sikorsky S-43 | Amph. | 2 | Twin Wasp S1EG | 750 | 7000 | 2tr 3bCP | 86·0 | 51·2 | 17·8 | 781 |
| 18 | Junker Ju 52 3m<br>Ju 52 | LWMF | 3<br>1 | Jumo 5<br>Jumo 4 | 420<br>600 | -<br>- | 3tr 2b<br>1tr 4b | 96·9 | 62 4<br>60 8 | 17 9<br>21·4 | 1189 |
| 19 | Latécoère 50-1 | HWMB | 3 | Hiso 12Jb | 400 | - | 2tr 1pu | 75·5 | 57·0 | 13·8 | 861 |

| No. | Tare & Equip't | Capacity: Gas | Capacity: Oil | Normal Load: Gas | Normal Load: Oil | Crew: No | Crew: Wt | Pass No | Pay Load | Dispos Load | Gross Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 1 | 58800 | 41000 | - | 25200 | 3762 | | | 75 | | 54400 | 123200 |
| 2 | 43454 | 38400 | | 9400 | | 4 | 880 | | 15800 | 38046 | 81500 |
| 3 | 50600 | | | | | | | | | 23400 | 74000 |
| 4 | 26670 | | | 21740 | | 3 | 705 | 0 | 2200 | 25930 | 52600 |
| 5 | 23100 | 24000 | 1800 | | | | | 50 | Var | 27900 | 51000 |
| 6 | 24900 | | | 22850 | | 4 | 705 | 0 | 2210 | 25700 | 50600 |
| 7 | 24640 | | | | | 8 | | | 1320 | 24860 | 49500 |
| 8 | 20526 | 14800 | | | | 4 | | | | 19514 | 40040 |
| 9 | 21945 | 7440 | 555 | 7995 | | 5 | | 32 | 8060 | 16055 | 38000 |
| 10 | 21025 | | | | | 3 | 705 | 19 | 7200 | 12025 | 33050 |
| 11 | 20460 | 5180 | 480 | 3420 | | 3 | 660 | 15 | 7460 | 11540 | 32000 |
| 12 | 16940 | | | 2530 | | 3 | 660 | 18 | 3960 | 7150 | 24090 |
| 13 | 17800 | 3520 | | | | 2 | 400 | 15 | 4300 | 4700 | 22500 |
| 14 | 12340 | 7460 | 151 | | | 4 | | | | 9700 | 22040 |
| 15 | 11720 | | | 8255 | | 4 | 775 | 0 | 1100 | 10130 | 21850 |
| 16 | 9780 | | | 10100 | | | 705 | | 1100 | 11870 | 21650 |
| 17 | 10200 | 5550 | 480 | 2400 | 180 | 3 | 510 | 0 | 1000 | 7650 | 17850 |
| 18 | 13290<br>10150 | | | | | 2 | | 14-17 | | 6980<br>6590 | 20270<br>16740 |
| 19 | 8200 | | | 2805 | | 2 | 352 | 10 | 2315 | 5480 | 13680 |

| No. | Wt Ratio | Loading: Wing | Loading: Power | Wing Power | Speed Ratio | Trans Effy | Max Speed: S.L. | Max Speed: Ht | Cruising: Speed | Cruising: % HP | Cruising: Ht | Speed | Ceiling: Abs | Ceiling: Serv | In rate Climb | Landg Speed | Range no wind: Rated | Range no wind: Flown |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
| 1 | 1.79 | 25.3 | 17 1 | 1 47 | | 0.397 | 130 | | | | | 105 | 6588 | | 230 | | 2000 | 1450 |
| 2 | 1.87 | 22 9 | 17.0 | 1 35 | | 0 495 | 156 | | | | | 125 | 16400 | | | | 2812 | |
| 3 | 1 46 | 18 5 | 15 0 | 1.24 | | 0.291 | 145 | | | | | 123 | 11000 | | | | 690 | |
| 4 | 1 97 | 18 8 | 20.5 | 0 91 | | 0 563 | 130 | | | | | 111 | 15000 | | | | 2980 | 2685 |
| 5 | 2 21 | 22 0 | 15 9 | 1 38 | 2 57 | 0.675 | 180 | 8000 | 180 | 60 | 6500 | 155 | | 18000 | 980 | 70 | 4000 | 2100 |
| 6 | 2.03 | 15.4 | 19 5 | 0.79 | | 0 544 | 130 | | | | | 110 | 15100 | | | | 2980 | |
| 7 | 2.01 | 20.7 | 19.0 | 1 09 | | 0.526 | 136 | | | | | 110 | | | | | 2000 | 1890 |
| 8 | 1.95 | 20.7 | 15.4 | 1.34 | | 0.488 | | 5000 | 152 | | | 129 | 13000 | | 400? | | 2484 | |
| 9 | 1.73 | 28.6 | 13 6 | 2.10 | 2 89 | 0.487 | 180 | 5000 | 188 | 70 | 12000 | 170 | 16000 | | 1000 | 65 | 3000 | 2500 |
| 10 | 1.57 | 18.4 | 13 8 | 1.33 | | 0.310 | 146 | 3280 | 149 | | | 124 | 16400 | | | | 680 | |
| 11 | 1.56 | 12.1 | 14 4 | 0 84 | 2.28 | 0.273 | | 5000 | 137 | | 5000 | 105 | 19500 | 17500 | 840 | 60 | 450 | |
| 12 | 1.42 | 17.7 | 11.5 | 1 54 | 2 48 | 0.248 | 164 | | | | | 146 | 18530 | | 850 | 69 | | |
| 13 | 1.27 | 12.3 | 15.2 | 0.81 | 2 02 | 0.147 | 123 | | | | | 93 | 14000 | 12000 | 615 | 61 | 651 | |
| 14 | 1 78 | 18.1 | 22 0 | 0.82 | | 0 630 | 143 | | | | | 130 | | | | | 2230 | |
| 15 | 1 87 | 15 6 | 16.8 | 0.93 | 1.89 | 0.428 | 130 | | | | | 110 | 14780 | | | 69 | 2980 | |
| 16 | 2.21 | 15 7 | 18.0 | 0 87 | | 0 550 | 130 | | | | | 111 | 15090 | | | | 2980 | |
| 17 | 1.75 | 22.9 | 11.9 | 1 92 | 3 08 | 0 461 | 186 | 7000 | 200 | 75 | 8000 | 181 | | 20000 | 1250 | 65 | 2000 | |
| 18 | 1 52<br>1.65 | 17.1<br>14 1 | 16 1<br>27 9 | 1.06<br>0 50 | | 0.398<br>0 571 | 161<br>121 | | | | | 144<br>104 | 19020<br>14100 | 17050<br>10826 | 900<br>450 | | -<br>1160 | |
| 19 | 1.67 | 15.9 | 11 4 | 1 40 | | 0.234 | 149 | 3280 | 144 | | | 127 | 18432 | | | | | |

| No. | Notes | References. | No. |
|---|---|---|---|
| 1 | 42 | 43 | 44 |
| 1 | Gross weight OVL rating Range 2000m with no pay load Climb and ceiling for 105600 lbs gross | Jour RAeS Sept 33 L'Aero Oct 30 Aero Dig Nov 31 | 1 |
| 2 | Estimated performance Range with normal fuel 620m. N Atlantic via Azores 24 pass S Atlantic 30 pass | Flight 24.1.35 Rev Aero Apr 35 Aero 23.1.35 Air Engng May 35 | 2 |
| 3 | Projected 1951 for Trans Mediterranean Service Max range 1300 m | Rev Aero Feb 31 Aero 20 2 35 | 3 |
| 4 | Mail carrier, normal gross 51300 Record Dec 34 Berre Ste Louis de Senegal. 2600m - S Atlantic 2010m 18h17. Record June 35 Cherbourg Ziguinchor Senegal 2685m 28h38 | L'Aero Dec 34 Air Engng May 35 Aerophile Jan 34 L'Aero Dec 31 | 4 |
| 5 | Range as mail carrier 4000m, with 52 pass 1200m, with 14 pass and 2000 lbs mail 3000m Alameda Calif - Honolulu 2100m - 17h 9 Aug 35. Tare ocean pass transp 28216lb Cost $325000 | Flight 24 1 35, 15.8.35 Aviat Jan 35 Aero 23.1.35 Aero Dig Jan Apr 35 | 5 |
| 6 | Postal aircraft - S Atlantic | Jane | 6 |
| 7 | Dakar-Natal Nov. 34. 1890m 16h25 Dec 34 15h45. Natal-Dakar. Dec 34 19h 7 Range against 31 mph wind For S Atlantic 4-1000 HP motors if passenger (60) carrier | Aero Dec 12 19 34 Air Engng Feb 34 Aerophile Jan 35 | 7 |
| 8 | Long range postal - S Atlantic Recent test, 16900 lbs fuel, payload 1320 lbs, gross 41900 take off 39 sec | Aero Jan 23 35 L'Aero Dec 34 Air Engng May 34 | 8 |
| 9 | Range 1200 with pay load shown. 3000 with 800 payload Record 1242m - payload 4409 lbs 157 mph. Miami - Virgin Isds return Mar 35 2500m fuel for 500m left Cost $275000 | Aviation Apr Aug 34 Jan 35 Jour RAeS Apr 35 Aero Dig Aug 34 | 9 |
| 10 | Civil version of Bizerte Performance for 30400 lbs gross Tanks for 1240m For Marseilles - Algiers service | L'Aero Dec 34 | 10 |
| 11 | Kent class, similar to Calcutta. Launched Feb 31. For Mediterranean service Actual performance at gross shown | Jane 34 Flight 17 10 30 | 11 |
| 12 | | Jane 34 Rev Aero May 32 | 12 |
| 13 | | Jane 33 | 13 |
| 14 | For Trans Atlantic service Mail, freight or passengers | Jane 34 Z F M Nr 15 33 | 14 |
| 15 | Postal Performance STAe test 1931 with full load | Jane 34 Air Engng Jan 31 | 15 |
| 16 | Postal | Jane 34 | 16 |
| 17 | Range as mail carrier at 12000 ft and 165 mph Range as a boat 2500m Range with 15 pass and 750 lbs mail - 750m. with 25 pass and no mail 390m | Flight Jan 24 June 20 35 Aviation Dec 34 Aero Dig Jul 35 | 17 |
| 18 | Freight or passenger Single motor, range on wheels 1240m | Jane 34 ZFM Nr 11. 33 | 18 |
| 19 | Commercial boat. Official test performance | L'Aero Aug 32 Jane 32 | 19 |

TABLE VI

AEROPLANES
(Civil)

| No | Aircraft: Builder, Number Name | Type | Engines: No | Engines: Type | Rated HP: HP | Rated HP: Height | Airscrews | Dimensions: Span | Length | Height | Lift'g Area | Weights: Tare & Equip't | Capacity: Gas | Capacity: Oil | Normal Load: Gas | Normal Load: Oil | Crew: No | Crew: Wt | Pass No | Pay Load | Dispos. Load | Gross Weight | Figures of Merit: Wt Ratio | Loading: Wing | Loading: Power | Wing Power | Speed Ratio | Trans Effy | Performance: Max Speed: SL | Max Speed: Ht | Cruising: Speed | Cruising: %HP | Cruising: Ht | Speed | Ceiling: Abs | Ceiling: Service | In rate Climb | Landg Speed | Range No wind: Rated | Range No wind: Flown | Notes | References | No |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
| 1 | A.N.T 15 Maxim Gorky | HWM | 8 | M.34 | 750<br>850 | - | 7tr.1pu2b | 210.0 | 107.0 | 34.6 | - | | | | | | 23<br>- | | 40<br>60-70 | 14000 | | 92600 | | | | | | | 149 | | | | | 137 | | | | | 1240 | | Propaganda aeroplane | Rev Aero Nov 34, Flight 4.8.34 Aero Dig Sept 35 | 1 |
| 2 | Junker G-38 von Hindenberg | HWM | 4 | Jumo 4 | 750 | - | 2tr 4b<br>2tr 2b | 144.4 | 75.6 | 22.6 | 3285 | 32800 | | | | | 7 | | 34 | 6600 | 20100 | 52900 | 1.61 | 16.1 | 17.6 | 0.91 | | 0.434 | 139 | | | | | 129 | 20990 | | 650 | | 2180 | | Range with 6600 lbs freight Range with L 88 engines 746m. Abs ceiling 3 engines 6560 | Air Engng Feb 30. L'Aero Mar 30 | 2 |
| 3 | A.N.T 14 | HWM | 5 | Jupiter 9AKK | 480 | - | 5tr 2b | 132.5 | 86.11 | 17.9 | 2585 | 23450 | | | | | | | 36 | | 14700 | 38150 | 1.63 | 14.7 | 15.9 | 0.93 | 2.92 | 0.323 | 136 | | | | | 116 | | 13120 | | 47 | | | | Jane 34 | 3 |
| 4 | Couzinet 70 Arc-en-Ciel | LWM | 3 | Hiso 12Nbr | 650 | - | 3tr 2b | 98.6 | 53.0 | 13-1½ | 970 | 16100 | 18600 | | 18690 | | | 882 | | 1323 | 20900 | 37000 | 2.30 | 38.2 | 19.0 | 2.01 | | 0.790 | 174 | | | | | 147 | | | | | 4230 | 2633 | Istres-Rio return Jan 33 crew 5 Istres-Pt Etienne Jan 12-13. 2633m 16h 30 St Louis-Natal Jan 16-17 1970m 14h 27 | Air Engng Feb 34 L'Aero Feb 33 Aero 25.1.33 | 4 |
| 5 | Fokker F XXXVI | HWM | 4 | Cyclone SGR 1800 F2 | 710 | 4100 | 4tr 3b CP | 108.2 | 78.8 | 19.8 | 1851 | 23760<br>24531 | 5380 | 435 | 3967 | | 4<br>5 | 705 | 16<br>32 | 4580<br>7163 | 11440<br>11835 | 35200<br>36366 | 1.48 | 19.6 | 12.8 | 1.53 | | 0.351<br>0.362 | - | 4100 | 186 | 75 | 9840 | 174 | 16400 | 14450 | 750 | | 960 | | Range at cruising speed with full tanks | Fokker Bull 34 | 5 |
| 6 | Short Scylla | B | 4 | Jupiter XFBM | 555 | 4000 | 4tr 4b | 113.0 | 86.3 | 29.6 | 2615 | 22650 | 4500 | | | | 4 | | 39 | | 9350 | 32000 | 1.41 | 12.2 | 14.4 | 0.85 | | 0.221 | | 5000 | 137 | | 5000 | 105 | | | | | 600 | | Range with full tanks, payload then 5250 lbs | Flight 5.4.34 | 6 |
| 7 | Handley Page HP.42 Hannibal Heracles | B | 4 | Jupiter XI<br>Jupiter XFBM | 550 | 4000 | 4tr 4b | 130.0 | 89.9 | 27.0 | 2990 | - | 3600 | | | | | | 18<br>38 | 7000<br>9000 | -<br>- | 28000<br>30000 | -<br>- | 9.4<br>10.0 | 12.6<br>13.5 | 0.74 | 2.40<br>2.47 | -<br>- | 120<br>127 | | | | | 95<br>105 | | | 845<br>670 | 50<br>51.5 | 500 | | | Jane 34 | 7 |
| 8 | Savoia S 74 | HWM | 4 | Piaggio Stella IXRC | 700 | - | 4tr 3b CP | 98.5 | 63.11 | 18.0 | 1291 | 17160 | 5210 | | 3300 | 330 | 4 | 990 | 24 | 6390 | 11880 | 29040 | 1.69 | 22.5 | 10.4 | 2.16 | | 0.395 | | 3280 | 199 | | 9840 | 186 | | 19680 | 950 | | 714 | | Range for fuel weight shown Same wing as S 55 boats Max permis gross 30870 lb | L'Aero June 35, Aero 6.2.35, Aero Dig Mar 35, Flight 31.1.35, 14.2.35 | 8 |
| 9 | Fokker F XXII | HWM | 4 | Wasp S3H1G | 550 | 5000 | 4tr 2b CP | 98.4 | 72.2 | 16.1 | 1399 | 18300<br>20056 | 4270 | 427 | 3152 | | 4 | 661 | 22 | 3385<br>4783 | 9750<br>8596 | 28030<br>28652 | 1.43 | 20.5 | 12.9 | 1.59 | 2.77 | 0.363<br>0.320 | | 5000 | 177 | 75 | 10500 | 165 | 17700 | 16100 | 700 | 64 | 932 | | Range with full tanks 3 for K L M, 1 for Sweden | Fokker Bull Aero 9.1.35 Flight 21.2.35 Rev Aero Dec 33 | 9 |
| 10 | Savoia S 79 | LWM | 3 | Piaggio Stella IXRC | 610 | - | 3tr 3b CP | 66.3 | 53.2 | 13.6 | 646 | 11000 | 10200<br>6150 | 720 | 2930 | 285 | 4 | 880 | 8 | 1200<br>2307 | 13300 | 24300 | 2.21 | 37.6 | 13.3 | 2.84 | 3.88 | 0.790 | 220 | 13120 | 248 | 70 | 13120 | 217 | | 23290 | 540 | 64 | 930 | | For MacRobertson Race - not ready tested Nov 34 speed 249 mph Performance with 6600 disposable To be used Rome-Rio | L'Aero June 35 Aero 12.12.34 6.2.35 | 10 |
| 11 | Armstrong Whitworth AW 15 Atalanta | HWM | 4 | Serval | 340 | SL | 4tr 2b | 90.0 | 71.6 | 14.0 | 1285 | 13900 | 2330 | 270 | 1600 | | | 550 | | 5000 | 7100 | 21000 | 1.51 | 16.3 | 15.4 | 1.06 | | 0.322 | | 3000 | 156 | | | 125 | 7000 | | 700 | | 660 | | For tropical service Normal range 400m Abs ceiling on 3 engines | Air Engng Aug 32 | 11 |
| 12 | Fokker F XX | HWM | 3 | Cyclone R 1820 F3 | 712 | 700 | 3tr 2b | 90.2 | 54.9 | 15.7 | 1033 | 13450 | 4120 | 148 | 4102 | | | 530 | | 2645 | 7278 | 20728 | 1.54 | 20.0 | 9.7 | 2.06 | | 0.320 | | 6890 | 202 | 75 | 12460 | 188 | 23288 | 21650 | 1000 | | 1056 | | Range for full tanks Normal fuel for 963m | Aero Dig Jan 34 Jane 34 Fokker Bull 33 | 12 |
| 13 | Dewoitine D 332 | LWM | 3 | Hiso 9Vr | 575 | - | 3tr 2b | 95.0 | 67.1 | 17.10 | 1032 | 12162 | 5070 | 2300 | 4850 | | | 596 | 8<br>16 | 3060 | 8506 | 20668 | 1.70 | 21.0 | 12.0 | 1.67 | | 0.430 | 187 | 6562 | 177 | 80 | 6562 | 175 | 21325 | | 1000 | | 1305 | 1305 | Performance for gross of 20200 lbs Endurance test with full tanks, gross 21395 lbs range 1305m Descendent of D-33 | Air Engng Feb 34 Jane 33 | 13 |
| 14 | Bernard 81GR | MWM R | 1 | Hiso 12Ybrs | 650 | - | tr 3b | 87.0 | 50.11 | 14.9 | 811 | 7270 | 11100 | | | | | | | | 13110 | 20380 | 2.80 | 25.1 | 31.4 | 0.80 | | 0.989 | | | | | | 98 | | | | | 6210 | | | Aeroph Oct 32 Jane 33 | 14 |
| 15 | Dewoitine D-33 Trait d'Union | LWM R | 1 | Hiso | 650 | - | tr 2b | 92.0 | 47.2 | 15.10 | - | 6830 | 12650 | 760 | | | | | | | 13470 | 20300 | 2.97 | - | 31.2 | - | | - | | | | | | | | | | | | 2900 | Record long range - Doret and LeBrix - closed circuit, Mar 31, 2900m 32h 18 | L'Aero May 31 | 15 |
| 16 | Bernard 80GR | MWM R | 1 | Hiso 12Nb | 650 | - | tr 2b | 80.4 | 48.6 | 13.1 | 753 | 6820 | 11100 | 700 | | | | | | | 12155 | 18975 | 2.78 | 25.2 | 29.2 | 0.86 | | 1.075 | 155 | | | | | 115 | 8200 | | | | 8070 | 5560 | Theoretical range Closed circuit record France Mar 31 5560m 59h 14 | L'Aero June 31 | 16 |
| 17 | Bleriot 110 Joseph le Brix | HWM R | 1 | Hiso 12 | 650 | - | tr 2b | 86.11 | 47.9 | 16.0 | 871 | 5500 | 11100 | 600 | | | | | | | 13420 | 18920 | 3.44 | 21.7 | 29.1 | 0.75 | | 1.030 | 137 | | | | | 100 | 6560 | | 275 | | 7825 | 5654 | Record duration 1930 67h 53 Record closed circuit 32 6703m New York - Rayak 33 5654m Paris-NY 34 3280m 38h 30 Istres Cap Verde Isd 35 3790m Range estimated on this 7456 | L'Aero Dec 30 Flight 28.3.35 | 17 |
| 18 | Dewoitine D 333 Antares | LWM | 3 | Hiso 9v Cyclone | 575 | - | tr 2b | 95.2½ | 56.7 | 17.7 | 861 | 9117 | 5120 | 504 | 4840 | | | 594 | | 3925 | 9359 | 18476 | 2.02 | 21.5 | 10.7 | 2.00 | | 0.433 | 188 | | | | | 160 | | | | | 1260 | | Range with normal load Development of the Emeraude | Flight 3.1.35 Jane 34 | 18 |
| 19 | Douglas DC 2 | LWM | 2 | Cyclone SGR-1820 F3 | 710 | 7000 | 2tr 3b CP | 85.0 | 62.0 | 16.4 | 940 | 12000<br>12200 | 3060 | 285 | 3060 | 285 | 2 | 353 | 8 | 2317 | 6000 | 18200 | 1.49 | 19.4 | 12.8 | 1.51 | 3.68 | 0.414 | 213 | 7000 | 210 | 75 | 12500 | 196 | 24800 | 23200 | 1090 | 58 | 1200 | | Closed circuit records May 35 1240m 4410 lbs pay load 191 mph - All up weight 24845 lb 3110m no pay load 169 mph 3110m 2200 lbs pay load 169 mph | Fokker Bull 34 35 Aero Dig Apr 35 | 19 |
| 20 | Curtis Condor | B | 2 | Cyclone SGR 1820 F3 | 710 | 7000 | 2tr 3b CP | 82.0 | 48.7 | 16.4 | 1208 | 11465 | 2100 | 225 | 2100 | 225 | | 510 | | 3200 | 6035 | 17500 | 1.53 | 14.5 | 12.3 | 1.18 | 3.65 | 0.354 | 190 | 8000 | 190 | | 8000 | 167 | 25000 | 23000 | 1200 | 52 | 716 | | Standard passenger transport day model | L'Aero Nov 33 Jane 34 | 20 |
| 21 | Fairey Long Range | HWM R | 1 | Lion XIA | 570 | - | tr 2b | 82.0 | 48.6 | - | 830 | - | 8903 | 641 | | | 2 | | | 0 | - | 17500 | - | 21.1 | 30.7 | 0.69 | | - | | | | | | 93 | | | | | | 5341 | Record Feb 33 Cranwell Walvis Bay 5341m 57h 25 Capacity 1157 gals gas (@ 7.7 lbs/gal) and 65 gals oil (@ 9.7 lbs/gal) | Air Engng Mar 33 Flight 16.2.33 | 21 |
| 22 | Fokker F XVIII Snipe | HWM | 3 | Wasp T1D1 | 525 | SL | 3tr 2b CP | 80.10 | 60.8 | 15.7 | 904 | 10805 | 3180 | 110 | 2492 | | 2 | 352 | | 3660 | 6505 | 17310 | 1.60 | 19.2 | 11.0 | 1.74 | | 0.374 | | 5248 | 168 | | 11152 | 157 | 20340 | 18700 | 950 | | 2860 | 2245 | Range with 6 extra tanks 1078 gal - gross 22046 lb Flight Holland - Dutch West Indies Dec 34 Porto Praia - Paramibo 2245m 17h 30 Range 620m with fuel and pay load shown | Fokker Bull Aerotec Dec 32 Flight 8.11.34 | 22 |
| 23 | Boeing 247D | LWM | 2 | Wasp S1H1G | 550 | 8000 | 2tr 3b CP | 74.0 | 51.4 | 12.2 | 836 | 8940 | 1640 | 150 | | | 2 | | 10 | 2582 | 4710 | 13650 | 1.53 | 16.3 | 12.4 | 1.32 | 3.31 | 0.404 | 202 | 8000 | 200 | | 12000 | 189 | 23300 | 21400 | 1000 | 61 | 835 | | Range at 62.5% HP and 8000 ft Range 745m at 75% HP and 8000 ft | Aero Dig Apr 35 Aeroph Nov 34 | 23 |
| 24 | Breguet 393T | S | 3 | Gnome 7Kds | 350 | 9971 | 3tr 2b | 68.0 | 59.10 | 12.2 | 723 | 7660 | | | 3125 | | | 1320 | | 880 | 5540 | 13200 | 1.72 | 18.3 | 12.6 | 1.45 | | 0.342 | 153 | | | | | 130 | | 19600 | | | 1000 | | As long range mail carrier | L'Aero Dec 34 | 24 |
| 25 | Pander Postjager | LWM | 3 | Whirlwind R975 E2 | 420 | - | 3tr 2b | 54.5 | 41.0 | 9.6 | 484 | 6655 | 3280 | 260 | | | 3 | | 0 | 1100 | 5445 | 12100 | 1.02 | 25.0 | 9.5 | 2.60 | 3.73 | 0.403 | 224 | | | | | 186 | | | | 60 | | | High speed mail carrier | Jane 34 | 25 |
| 26 | Fiat APR 2 | LWM | 2 | Fiat A59R | 700 | 6562 | 2tr 2b CP | 64.0 | 47.0 | 11.8 | 636 | 8820 | | | 2870 | | 3 | | 12 | | 3150 | 11970 | 1.36 | 18.8 | 8.5 | 2.20 | 3.78 | 0.231 | | 6560 | 238 | | | 205 | | | | 63 | 1242 | | With extra tanks | L'Aero Feb 35 | 26 |
| 27 | Lockheed Electra 10C | LWM | 2 | Wasp SC1 | 450 | 6000 | 2tr 2b CP | 55.0 | 38.7 | 10.1 | 458 | 6710 | 1560 | 127 | | | 2 | | 10 | 2200 | 3590 | 10300 | 1.54 | 22.5 | 11.5 | 1.96 | 3.16 | 0.383 | | 6000 | 205 | | 12000 | 194 | | 22750 | 1090 | 65 | 675 | | Price $50000 | Aero Dig Apr 35 | 27 |
| 28 | Couzinet 33 | LWM R | 3 | Gipsy III | 120 | - | 3tr 2b | 53.0 | 35.11 | 9.4 | 369 | 3632 | 3670 | | | | | | | | 4323 | 7955 | 2.19 | 21.6 | 22.1 | 0.98 | | 0.709 | | | | | | 118 | | | 670 | | 3350 | | | L'Aero Dec 32 Jane 33 | 28 |
| 29 | Northrop Delta 1D | LWM | 1 | Cyclone SR1820F3<br>Hornet S0 | 710<br>700 | 7000<br>6000 | tr 2b CP | 47.10 | 33.1 | 11.4 | 363 | 4200<br>4540 | 1968<br>1915 | 165<br>144 | | | 1-2 | | 4-6 | 1295 | 2810 | 7350 | 1.62 | 20.3 | 10.4 | 1.96 | 3.72 | 0.416 | | 4000 | 216 | | 15000 | 192 | | 22000 | 1200 | 60 | 1700 | | Freight version Gamma Special model for Hawkes Vancouver Quebec - two stops Aug 33 17h 10 also Los Angeles - New York 2520m 13h 37 Price $37500 | Aero Dig Apr 35 Aviat Apr 35 | 29 |
| 30 | Caudron C440 | LWM | 2 | Renault | 210 | - | 2tr 2b CP | 57.9 | 43.7 | 6.5 | 430 | 3947 | | | | | 2 | | 6 | | 2668 | 6615 | 1.67 | 15.4 | 15.8 | 0.98 | 3.05 | 0.515 | 180 | | | | | 162 | 16400 | | | 59 | 1242 | | Estimated performance Engines non supercharged versions of Renault Special | Flight 14.6.34 | 30 |
| 31 | Airspeed Viceroy | LWM R | 2 | Cheetah | 315 | 7000 | 2tr 2b | 52.4 | 34.6 | 9.6 | 299 | 3900 | 1950 | - | | | 2 | | | | 2400 | 6300 | 1.61 | 21.1 | 9.8 | 2.10 | 3.14 | 0.348 | | 7000 | 210 | | 7000 | 190 | | | 1000 | 67 | 1400 | | As for MacRobertson Race - commercial has smaller tank and carries 6-8 passengers - disposable load about 2500 lbs | Jane 34 | 31 |
| 32 | Bellanca Senior Pacemaker | HWM | 1 | Whirlwind R 975 E2 | 420 | - | tr 2b | 50.6 | 27.11 | 8.6 | 311 | 3000 | 1200 | 90 | 1140 | | 1 | 170 | 5 | 850 | 2350 | 5350 | 1.78 | 17.2 | 12.7 | 1.35 | 2.80 | 0.453 | 165 | | | 75 | 12000 | 155 | | 18000 | 900 | 59 | 1360 | | Price $19500 | Aero Dig Apr 35 | 32 |
| 33 | De Havilland DH 88 Comet | LWM R | 2 | Gipsy Six Special | 224<br>235 | SL | 2tr 2b CP | 44.0 | 29.0 | 9.0 | 189<br>212 | 2840<br>2983 | 1870<br>1962 | 126<br>155 | | | 2<br>2 | 400<br>400 | | | 2480<br>2567 | 5320<br>5550 | 1.67<br>1.86 | 28.1<br>26.1 | 11.9<br>11.8 | 2.37<br>2.21 | 3.01 | 0.625<br>0.612 | 235 | | | | | 225 | 19000 | | 900<br>1200 | 78 | 2900 | 2530 | England - Baghdad 2530m 12h 40 Belgian Reine Astrid range 2000m with 200 lb mail France tankage for 2250m with 220 lb mail | Flight 27.12.34 Jou RAeS Mar 35 | 33 |

The particulars of the aircraft listed indicate the recent and present position of commercial aircraft with particular reference to range, capacity and size and may serve as a guide in developing aircraft suitable for the Atlantic service.

### Factors Governing Air Transport Efficiency

The factors controlling the efficiency of air transport are those governing the attainment of maximum range. Improvements and economies which extend range also improve economy of transport over shorter distances. Thus the steady increase in the world distance record is perhaps a surer measure of the progress of air transport than is the raising of the speed record.

A study of the factors affecting range will therefore be useful in considering aircraft for use for the transatlantic service. From such a study, it will be evident that the principal factors affecting economy of operation are the aerodynamic efficiency of the aircraft and airscrew, the structural efficiency of the aircraft, the power plant efficiency and the efficiency of navigation, including choice of height, speed and course with respect to weather conditions.

These and other considerations involved in determining the characteristics of the aircraft to be used for the service are discussed briefly in the following paragraphs.

### Type of Aircraft

In considering the question of the aircraft for the service, the first decision to be made is that of the type of aircraft—aeroplane, flying boat, seaplane or amphibian. On this point, there are two schools of thought, one favouring aeroplanes, the other flying boats.

From the standpoint of efficiency, the modern flying boat, particularly in the larger sizes, is as efficient and may be more efficient than the corresponding land machine, as the figures of Tables V-VII and the plots of Figs. 20 and 25 indicate. Even with undercarriage retracted, the large commercial aeroplane is not more efficient than a well designed boat and it is probable that the efficiency of the latter will be improved still further in the future by fairing the steps in flight, retracting wing tip floats,[23] or improving the stub wings.

From the standpoint of structural efficiency, the modern boat weighing, with load, 30,000 lb. or

[23] This is already being done. See number 11A, Fig. 17.

TABLE VII

FLYING BOATS, SEAPLANES, AMPHIBIANS
(Civil)

| No. | Aircraft: Builder, Number Name | Aircraft: Type | Engines: No | Engines: Type | Engines: Rated HP: HP | Engines: Rated HP: Height | Airscrews | Dimensions: Span | Dimensions: Length | Dimensions: Height | Dimensions: Lifting Area | Weights: Tare & Equip't | Weights: Capacity: Gas | Weights: Capacity: Oil | Weights: Normal Load: Gas | Weights: Normal Load: Oil | Weights: Crew: No | Weights: Crew: Wt | Weights: Pass No | Weights: Pay Load | Weights: Dispos Load | Weights: Gross Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 7A | Short Empire Caledonia | HWMB | 4 | Pegasus Xc | 740 | 3500 | 4tr 3bl CP | 114.0 | 88.0 | 31-10 | 1500 | 27340<br>25000 | 4560<br>16100 | 400 | | | 5<br>3 | 800 | 16-24 | 7400<br>1000 | 13160<br>20000 | 40500<br>45000 |
| 8B | Lioré et Olivier H-47 | HWMB | 4 | Hiso 12Ybrs | 880 | 8200 | 2tr 2pu 3b | 104.0 | 69.6 | 23.6 | 1450 | 22200 | 14300 | | | | 5 | | 4 | 2900 | 17500 | 59500 |
| 8A | Sikorsky S-42A | HWMB | 4 | Hornet S1EG | 750 | 7000 | 4tr 5bl CP | 118.2 | 68.0 | 17.4 | 1340 | 23105 | 7995 | | | | 5 | | 32 | 8060 | 16895 | 40000 |
| 9A | Loire 102 Bretagne | HWMB | 4 | Hiso 12Xgrs | 720 | | 2tr 2pu 5b | 111.6 | 75.6 | 22.9 | 1480 | 20560 | 14190 | | | | 4 | 800 | | 2205 | 17240 | 37800 |
| 10A | Lioré et Olivier H 246 | HWMB | 4 | Hiso 12Xirs | 720 | | 4tr 3bl | 104.0 | 69.6 | 23.3 | 1410 | 21600 | 4740 | | | | | | 24 | 6650 | 11400 | 55000 |
| 11A | Douglas DF | HWMB | 2 | Cyclone SGR-1820 G2 | 1000 | | 2tr 3bl CP | 95.0 | 69-11 | 20.2 | | 16850 | 9720 | | | | 4 | | 32<br>12 | 2000 | 11650 | 28500 |
| 16A | Dornier Do 18 Zephir | HWMB | 2 | Junker Jumo 205 CV | 500<br>560 | | 1tr 1pu 3bl | 77.9 | 63.3 | 17-10 | 1054 | 15145 | 6061 | | | | 4 | 704 | | 530 | 8426 | 20240 |
| 16B | Mayo Upper Mercury | HWMF | 4 | Napier Rapier V | 315 | 10000 | 4tr 2bl | 73.0 | 51.0 | 20.3 | 611 | 9760 | | | | | | | | | | 20000 |
| | Mayo Lower Maia | HWMB | 4 | Pegasus X | 810<br>850 | 4000 | 4tr 3bl CP | 114.0 | 84-11 | 32-7 | 1750 | | | | | | | | 18 | | | |

| No. | Figures of Merit: Wt Ratio | Loading: Wing | Loading: Power | Wing Power | Speed Ratio | Trans Effy | Performance: Max Speed: SL | Max Speed: Ht | Cruising Speed: Speed | Cruising: ½HP | Cruising: Ht | Speed | Ceiling: Abs | Ceiling: Service | In rate Climb | Landg Speed | Range Nowind: Rated | Range: Flown | Notes | References | No |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
| 7A | 1.48<br>1.64 | 270<br>500 | 13.7<br>15.2 | 1.97 | 2.26 | 0.332<br>0.501 | 200 | 5500 | 200 | 60 | | 165 | 20000 | | 950 | 73 | 760<br>3300 | 2500 | Range still air 1000 lbs mail, crew 3, at 160 m.p.h. 3300 miles Flew 1937 Southampton-Alexandria 2500 miles -13½ hrs, crew 5, ballast 800 lbs. | Flight 21.1.37, SBAC. | 7A |
| 8B | 1.78 | 273 | 11.2 | 2.45 | - | 0.443 | | 8200 | 225 | 65 | 6560 | 180 | 22960 | | | | 2484 | | Long range transatlantic. Gross 39685 lbs take-off 20 secs | Flight 14.1.37, L'Aero Nov 36 Jane 1936 | 8B |
| 8A | 1.93 | 299 | 15.3 | 2.24 | 2.62 | 0.479 | | 7000 | 190 | 73<br>70 | S.L.<br>12000 | 160<br>170 | 20000 | | 800 | 65 | 1200 | | Take-off 30 secs | Jane 1936 | 8A |
| 9A | 1.84 | 256 | 13.1 | 1.95 | | 0.479 | 198 | 9840 | 192 | 55 | 13200 | 155 | 19700 | | | | 2640 | | For S Atlantic. Range with 4 pass. 1430 lbs mail | L'Aero July 36 Rev Aero Aug 36 L'Aerophile July 36 | 9A |
| 10A | 1.56 | 234 | 11.5 | 2.04 | | 0.310 | | 6560 | 208 | | | 157 | 25600 | | | | 930 | | Transatlantic | L'Aerophile Nov 36 | 10A |
| 11A | 1.69 | | 14.3 | | 2.85 | 0.487 | | 6500 | 185 | 75 | 9000 | 167 | 16000 | | | 65 | 2700<br>3280 | | Long range trans oceanic Range, no pay load, 75% power 2700 m 62½% power 2880 m. Max range 3280 m. | Aviation Jan 37 Aero 9.12.36 | 11A |
| 16A | 1.54 | 19.2 | 18.4 | 1.04 | 2.77 | 0.420 | 155 | | | | | 131 | | 14432 | | 56 | 2670 | 2390 | Ocean mail carrier. Speed 130 mph cons 2.29 lbs/m, at 112 mph cons 2.03 lbs/m Flew Azores-New York 2390 m 22 hrs 9.9.36 | Aviation Oct Nov 36 Aero Orig Oct 36 Rev Aero Feb 36 | 16A |
| 16B | 2.05 | 32.7 | 15.9 | 2.06 | | 0.650 | | | | | | 160 | | | | | 5380 | | | June 36. SBAC. | 16B |
| | | | | | | | | | | | | | | | | | | | | June 36 SBAC. | |

AEROPLANES

| No. | Builder, Number Name | Type | No | Engine Type | HP | Height | Airscrews | Span | Length | Height | Lifting Area | Tare & Equip't | Gas | Oil | Normal Gas | Normal Oil | Crew No | Crew Wt | Pass No | Pay Load | Dispos Load | Gross Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6A | Bloch 160 | LWM | 4 | Hiso 12Xbrs | | | | 90.0 | 87.0 | | 1180 | 19800 | 4900 | | | | 4 | 700 | 20<br>8 | 1100 | 11050 | 30850 |
| 10A | Bloch 300 Pacifique | LWM | 3 | Gnome Mistral Major or K14 | 900 | 4900 | 3tr 3bl | 91-10 | 82-0 | 16.5 | 1150 | 15750 | 3300 | | | | 4 | | 50 | 7006 | 10900 | 26650 |
| 10B | Dewoitine D 338 | LWM | 3 | Hiso 9Vd | 575 | | 3tr | 96.6 | 72.6 | | 1065 | 12680 | | | | | | | | | 11570 | 24250 |
| 10C | Douglas DC-3 DST | LWM | 2 | Wright SGR 1820 P&W SB6 1830 | 850 | 3800<br>8000 | 2tr. CP | 95.0 | 64.5 | 15.0 | 987 | 15140 | 4960 | 500 | | | | | 21<br>14 | | 8860 | 24000 |
| 15A | Bloch 220 | LWM | 2 | Gnome K14 | 900 | | | 74.9 | 46.8 | 14.9 | 775 | 14552 | 2310 | | | | 3 | | 16 | 2730 | 5248 | 19800 |
| 15B | Caproni 123 | LWM | 2 | Gnome K14 | 900 | | 2tr 3bl | 91.5 | 59.8 | 19.8 | 986 | 11686 | 3820 | | | | 2 | | 20 | | 7718 | 19404 |
| 22A | Junker Ju 86 Buckeberg | LWM | 2 | Jumo 205, Kestrel XVI, Hornet | 750 | 700 | 2tr CP | 74.0 | 57.6 | 15.9 | 882 | 10550 | 1050 | 195 | | | | | 10 | | 5900 | 16450 |
| 22B | Lockheed 14 | LWM | 2 | Cyclone GR 1820 G3 | 600 | 15000 | 2tr 3bl CP | 65.6 | 44.4 | 11.6 | 551 | | | | | | 3 | | 11 | | | 15000 |
| 28A | Caudron C 640 Typhon | LWM | 2 | Renault | 220 | | 2tr 2bl | 48.6 | 55-11 | 9-10 | 301 | 4400 | 2706 | | | | 2 | 396 | | 440 | 5534 | 7920 |

| No. | Wt Ratio | Wing Loading | Power Loading | Wing Power | Speed Ratio | Trans Effy | Max Speed SL | Max Speed Ht | Cruising Speed | ½HP | Ht | Speed | Ceiling Abs | Ceiling Service | In rate Climb | Landg Speed | Range Rated | Range Flown | Notes | References | No |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6A | 1.56 | 259 | | 2.32 | 3.48 | | 248 | | | 57 | | 186 | 23000 | | | 65 | 1550 | | Specially constructed for Air Afrique | L'Aero Nov 36. Jane 36 | 6A |
| 10A | 1.69 | 23.6 | 9.9 | 2.59 | 4.52 | 0.420 | | 6560 | 208 | 55 | 4920 | 170 | | | | 46 | 746 | | Est performance Range with max fuel and pay load 5940 lbs. | Flight 7.1.35 Jane 1936. Jane 36 | 10A |
| 10B | 1.92 | 22.7 | 14.1 | 1.62 | | 0.540 | 187 | | | | | 161 | 17200 | | 482 | | | | | L'Aerophile Sept. 36 | 10B |
| 10C | 1.58 | 24.3 | 14.1 | 1.72 | | 0.470 | | 7000 | 213 | | 10000 | 180 | 23900 | | 950 | | | | DST Sleeper Performance with G2 Cyclones Guaranteed within 2% on speed, 5% on rest Ceiling one motor 7500 | Aero 26.8.36 Flight 27.8.36 L'Aero Oct 36 | 10C |
| 15A | 1.36 | 25.5 | 11.0 | 2.32 | | 0.237 | 198 | | | 62 | | 162 | | | | | 620 | | Test performance fuel and oil for 620 m. | L'Aero Nov. 36 | 15A |
| 15B | 1.66 | 19.7 | 11.8 | 1.83 | 3.08 | 0.361 | 193 | 6790 | 211 | 70 | 6790 | 168 | | 24700 | 800 | 68 | 932 | | | Aviation Oct 35 Jane 36 | 15B |
| 22A | 1.56 | 18.3 | 11.0 | 1.70 | 3.76 | 0.413 | | 700 | 226 | | 12000 | 210 | 23200 | | | 60 | 665 | 5610 | Range at 210 mph 12000 ft, with 247 gals gas Flew Dessau-Bathurst, non-stop 3610 m in 20 hrs 22.8.36 | Aero 26.8.36 Flight 27.8.36 Aerotec Oct 36 | 22A |
| 22B | | 27.2 | 8.9 | | | | 238 | 8700 | 265 | 66<br>83 | 15000 | 204<br>228 | 28000 | | 1700 | 65 | 600<br>1000 | | | Aviation Mar 37 | 22B |
| 28A | 1.90 | 26.3 | 17.6 | 1.46 | | 0.818 | 229 | | | 75 | | 205 | 23000 | | | 67 | 3167 | | Mail carrier Range at 199 mph nowind | L'Aero Nov 36. Jane 36. Rev Aero Feb 36 | 28A |

over, is seen from the tabulated figures for the ratio of gross to tare weight and the plot of Fig. 22 to be generally superior to the wheeled aircraft. There is some indication from the figure that, as the size becomes greater, the structural weight of boats becomes proportionately less.

As the size is increased, the displacement and normal loading of the hull increases as the cube of the linear dimensions. At the same time, the larger the boat, the better the take-off, since the hump speed occurs later when the wings are carrying a larger part of the load and, due to its lower centre of gravity, the stability of the larger boat on the water is better.

Thus the large flying boat is advantageous structurally, hydrodynamically and aerodynamically.

The service being over water, it is considered by some that the flying boat should be used because of its ability to alight and remain afloat in an emergency. This reason in itself is not adequate. A wheeled aircraft, properly designed and with retracted undercarriage, could safely alight on the sea and, if provided with watertight compartments and wings, could remain afloat in fair weather probably as long as a flying boat.[24] It is contended that aircraft forced down at sea have remained afloat and crew, load and machine have been recovered on several occasions in the South Atlantic and, on at least one occasion, a land machine remained afloat some days in the North Atlantic. But in these cases, the weather was fair, with no sea. No existing aircraft, if forced down, could long survive North Atlantic seas in rough weather. The advantage of the boat in this respect is that, if forced down by a minor defect, in fair weather, it can take off again after repairs have been

[24]Service aircraft, operating from carriers, are now built with watertight compartments.

EXPLANATORY NOTES—TABLES V-VII

Col. 3—Type: HWM, High wing monoplane. B, Flying boat.
LWM, Low wing monoplane. F, Float seaplane.
MWM, Mid wing monoplane. Amph., Amphibian.
B, Biplane.
S, Sesquiplane. R, For attack on record.
Col. 8—Airscrews: tr., tractor; pu, pusher; b., blades.
C.P., Controllable or variable pitch.
Cols. 9-12—Dimensions in feet.
Cols. 13-23—Weights in pounds.
Col. 13—Weight empty plus fixed equipment.
Col. 24—Weight Ratio: Gross weight divided by tare plus equipment.
Col. 25—Wing Loading: Gross weight divided by lifting area.
Col. 26—Power Loading: Gross weight divided by total rated power.
Col. 27—Wing Power: Total rated power divided by lifting area, i.e., wing loading divided by power loading.
Col. 28—Speed Ratio: Maximum speed divided by landing speed.
Col. 29—Transport Efficiency

$$= \frac{\text{Disposable load (short tons)} \times \text{cruising speed}}{\text{Total rated power}}$$

= Ton miles per hour per hp.
Col. 30—S.L.: Sea level.
Cols. 30, 32, 35, 39: Speeds: miles per hour.
Col. 38—Rate of Climb: feet per minute.
Cols. 40, 41—Range: miles.
Col. 43—Abbreviations:

| | |
|---|---|
| Air Engng., | Aircraft Engineering. |
| Aero., | Aeroplane. |
| Aero Dig., | Aero Digest. |
| Aeroph., | Aerophile. |
| Jane, | All the Worlds Aircraft. |
| ZFM, | Zeit für Flug. und Motor. |
| Aviat., | Aviation. |
| L'Aero., | L'Aeronautique. |
| Rev. Aero., | Revista Aeronautica. |
| Jour. R.Aes., | Journal Royal Aeronautical Society. |
| Aerotec., | L'Aerotecnica. |

*Fuel and Oil Weights.*
Gasoline, 7.2 lb. per Imp. gal., 6.0 lb. per U.S. gal., 1.56 lb. per litre.
Oil, 9.0 lb. per Imp. gal., 7.5 lb. per U.S. gal., 2.00 lb. per litre.

*Notes*
①Lifting area includes stub wings.
②Cruising speed assumed 85 per cent of maximum speed.
③Stalling speed.
④Entry data for MacRobertson Race—Flight 23-9-34.

made, or possibly taxi toward a rescue ship. The psychological effect of this factor on the crew should not be overlooked.

The decision as between aeroplane and flying boat thus seems to depend largely on conditions at the terminals. The boat possesses the advantage that, using available harbours, construction of costly aerodromes is avoided. With increase in weight of wheeled aircraft, the cost of constructing runways capable of supporting the heavy wheel loads becomes high. In the case of oceanic or coast routes, harbours are at sea level and a high rate of climb is normally not necessary. The cost of fuel and supplies is generally lower at seaboard.

On the other hand, the use of boats is dependent on the availability of fog and ice-free harbours and on the ability to make blind landings on water. While blind alightings on water, using radio, have not been attempted, insofar as is known, there seems to be no technical difficulty involved. Without radio, dependence must be placed on an accurate and sensitive height indicator. With ample room, blind landings have been made by coming in on a flat glide until a weight hanging a known distance below the hull strikes the water.

The wheel undercarriage of aeroplanes, particularly of large size, is heavy and necessitates heavy structural members to take the landing loads. The working parts of the undercarriage require maintenance. If retractable, the retracting gear adds to the weight, complexity and mainnance of the undercarriage. In addition, for winter operation over the Atlantic, provision must be made for take-off on wheels from land and alighting on skis on ice or snow, or vice versa. Such provision can be made without serious sacrifice of efficiency.

The float seaplane is not considered suitable for the service. Compared with the boat, it is less seaworthy, has less reserve buoyancy (about 100-150 per cent, as compared with possibly 500 per cent for the boat) and is not capable of development to the large sizes possible with the boat. The seaplane is less efficient structurally and aerodynamically in the larger sizes.

Although, in discussions of the type of aircraft for an Atlantic service, the amphibian is generally dismissed as unsuitable, the figures tabulated in Table V for number 17, the Sikorsky S-43 amphibian, indicate that, both structurally and aerodynamically, the amphibian can be made quite efficient, which, coupled with its versatility in landing, amply justifies the amphibian receiving serious consideration. The weight of its landing gear should be little larger proportionately than the retractable undercarriage of land machines and it should possess the low structural weight and other advantages of the flying boat as is indicated by the plots for number 17 in Figs. 20-23.

### Monoplane or Biplane

Present practice in commercial aircraft favours the monoplane. This is indicated in Tables V-VII and the corresponding figures. Insofar as is known, no large commercial biplane is now under construction anywhere. It is also worthy of note that the three major world records are held by monoplanes.

This question is largely associated with that of aspect ratio or span. The span of the equivalent monoplane (same induced drag) is greater than that of the biplane. For maximum economy, flying at maximum $L/D$ aspect ratio is important, but its importance decreases with increase in operating speed and reduction in incidence below that of maximum $L/D$. Aspect ratio is also important in connection with climb and, for boats, take-off. The aspect ratio determined by these considerations has generally to be reduced, for practical reasons, such as housing, or in the case of boats, to provide tip clearance, in roll, on the water.

The parasite drag of the wing bracing of the biplane, even with high wing loading and few interplane struts, reduces the aerodynamic cleanliness as compared with the monoplane and, in consequence, for a given cruising speed, higher power is required, with greater fuel consumption (see Fig. 23).

At the same time, it appears from the weights of the few biplanes tabulated in Tables V and VI and plotted in Fig. 22, that the structure weight of biplanes is rather higher, instead of lower, than that of monoplanes.

The adverse effect on economy of a loss of aerodynamic efficiency is greater than that of the same relative increase in weight.

Figures 20 and 21 indicate that the transport efficiency of biplanes is generally less than that of monoplanes. For economy in long range operation, a good monoplane generally will be superior to a good biplane.

For flying boats, seaworthiness is important and from this standpoint the monoplane is the better. Its stability on the water, as when taxying, is greater since the side area is neither as large nor as high and the rolling moment is therefore less than for the biplane. Good wave clearance is provided by the high wing monoplane.

The cost of construction is largely influenced by the number of parts and hence generally the biplane structure, with its larger number of struts and fittings, will be higher, not only in initial cost, but also in cost of maintenance.

It is therefore evident that, for a service of the nature of that over the Atlantic, the monoplane is preferable.

### Wing Loading

For economy of operation in long range commercial aircraft, high wing loading and moderately high power loading are essential. Generally speaking, the higher the wing loading, the closer does the cruising speed approach the speed of greatest aerodynamic efficiency. But with high wing loading, landing speeds are generally dangerously high and take-off difficult. For instance, with a wing loading of—

20 lb. per sq. ft., the stalling speed is 70 m.p.h. or 101 f.p.s.
30 lb. per sq. ft., the stalling speed is 85 m.p.h. or 125 f.p.s.
40 lb. per sq. ft., the stalling speed is 98 m.p.h. or 145 f.p.s.
50 lb. per sq. ft., the stalling speed is 110 m.p.h. or 162 f.p.s.

These speeds may be lowered and take-off and landing thereby improved by the use of slots, flaps and similar lift increasing devices and by wheel and air brakes. Variable pitch airscrews afford extra power for take-off and increased airscrew efficiency.

Because the weight of the fuel consumed in long flights is large, the gross weight and with it the wing and power loading, are much reduced at the end of the flight and the aircraft lands at a much lower speed than that at which it took off. In other words, the characteristics of the aircraft change during a long flight. If determined by the take-off conditions, the wing loading is unduly low at the end of the flight and the excess area over that required for alighting and the additional power provided for take-off reduce the pay load and range. In a general way, for efficient operation, the wing loading should be determined by conditions at the end of the flight and the power loading by the average cruising conditions during the flight.

Some of the foregoing points are illustrated by the performance curves of Fig. 24. The curves apply in a general way to a well designed modern long range flying boat, of gross weight 38,000 lb., rated power 2,800 hp. and a weight ratio of 2:1. Curves $A$ (full lines) apply to the fully loaded aircraft with wing loading 28.6 lb. per sq. ft. and power loading 13.6 lb. per hp.; curves $B$ (dotted lines) to the same aircraft, after flying at 160 m.p.h. a distance of 1,800 miles against a 30 m.p.h. head wind and using 14,000 lb. of fuel; curves $C$ (dashed lines) to the aircraft with the same engine installation, when loaded up to a gross weight

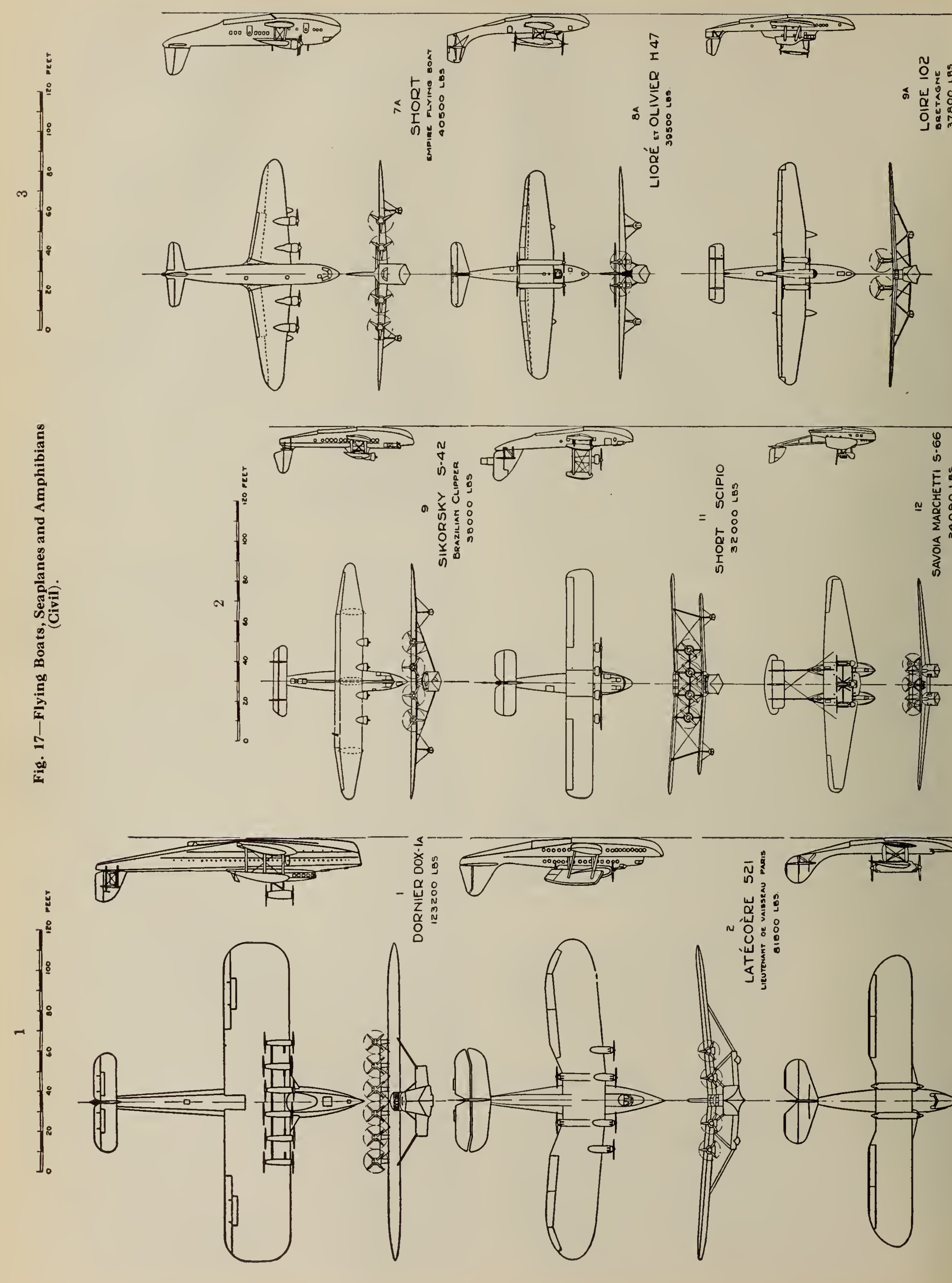



Fig. 17—Flying Boats, Seaplanes and Amphibians (Civil).

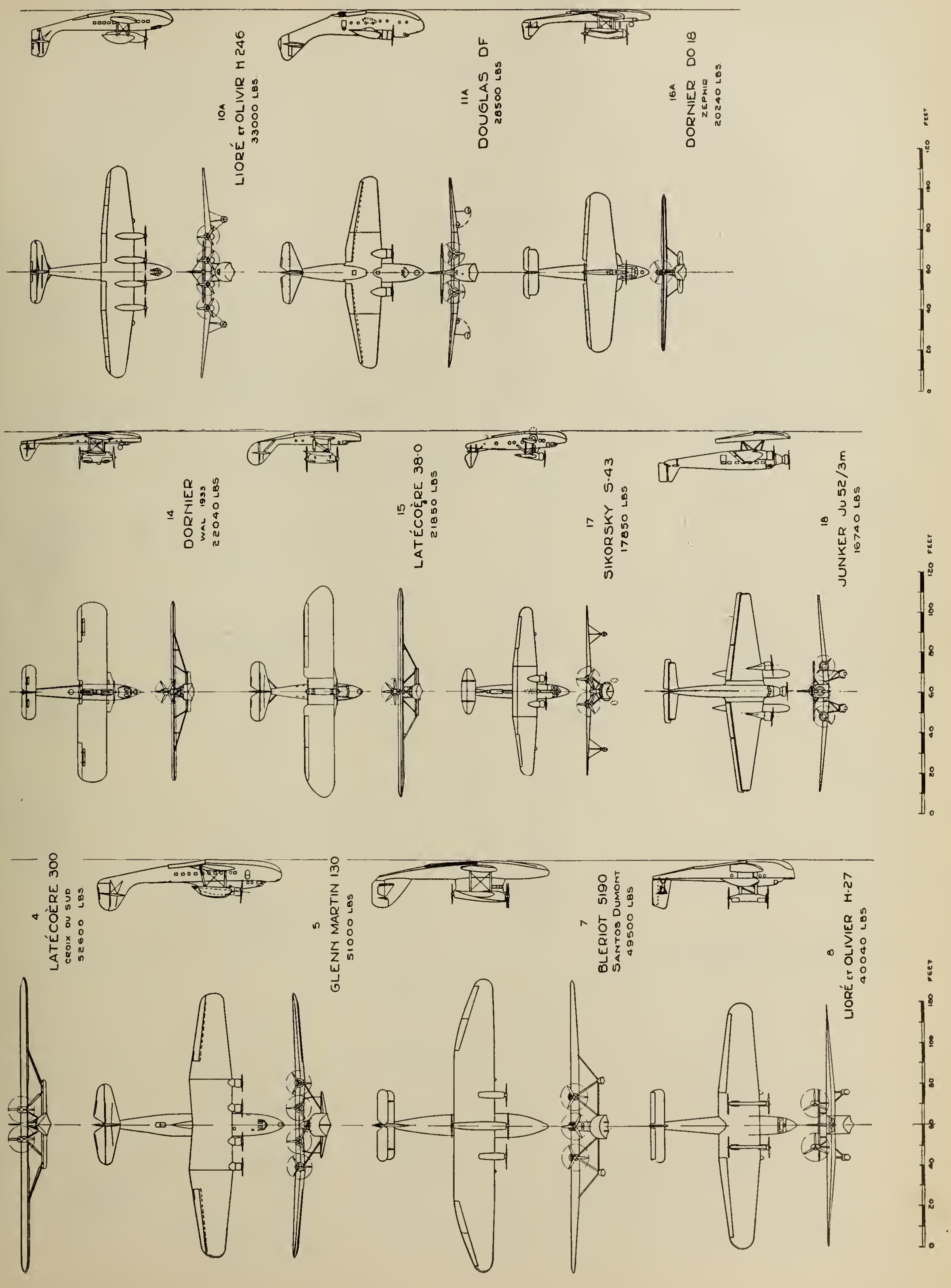
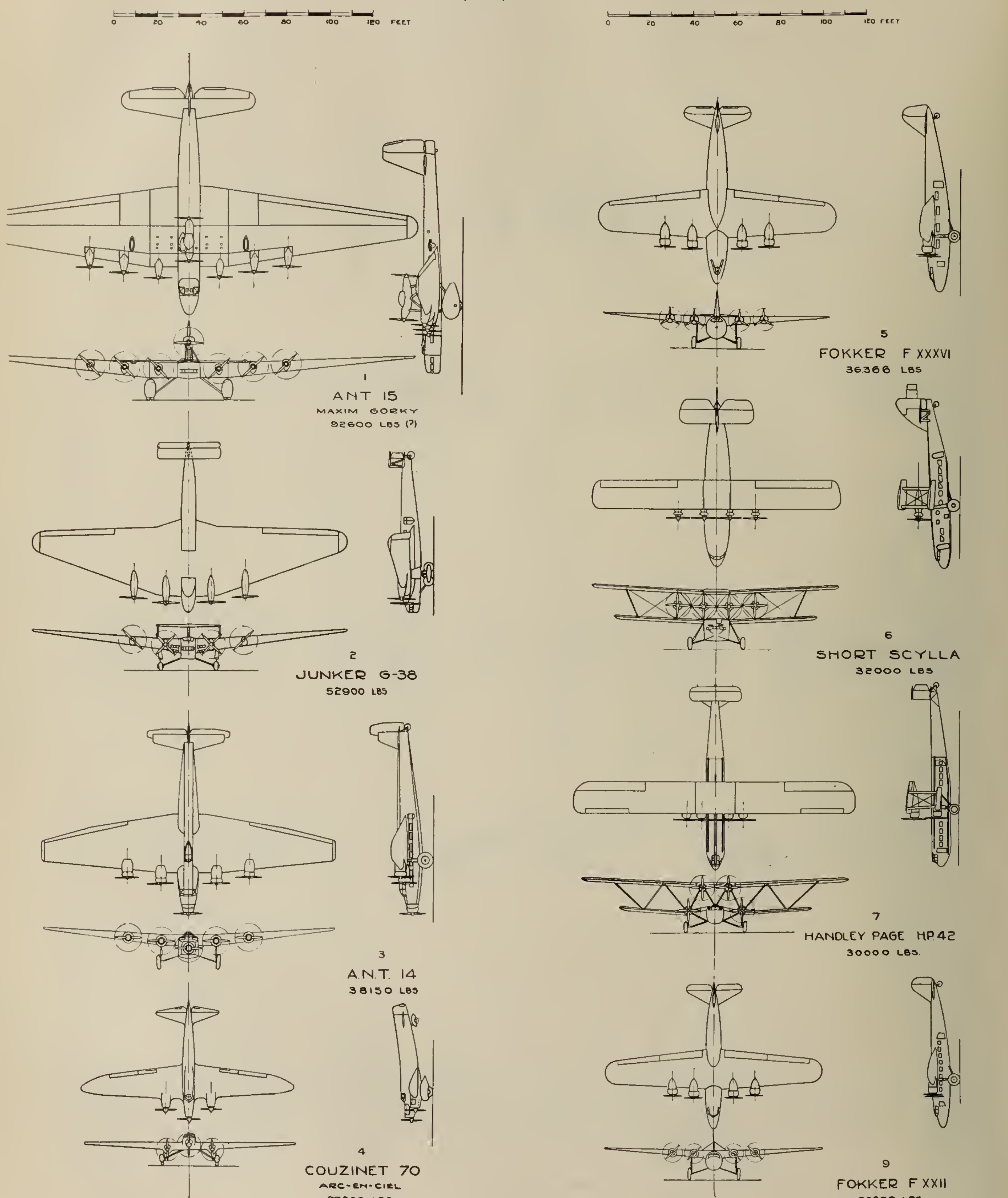

10A
LIORÉ ET OLIVIR H 246
33000 LBS
11A
DOUGLAS DF
28500 LBS
16A
DORNIER DO 18
ZEPHIR
20240 LBS
14
DORNIER
WAL 1933
22040 LBS
15
LATÉCOÈRE 38·0
21850 LBS
17
SIKORSKY S-43
17850 LBS
18
JUNKER Ju 52/3m
16740 LBS
4
LATÉCOÈRE 300
CROIX DU SUD
52600 LBS
5
GLENN MARTIN 130
51000 LBS
7
BLERIOT 5190
SANTOS DUMONT
49500 LBS
8
LIORÉ ET OLIVIER H·27
40040 LBS
0 20 40 60 80 100 120 FEET

**Fig. 18—Aeroplanes**
**(Civil)**



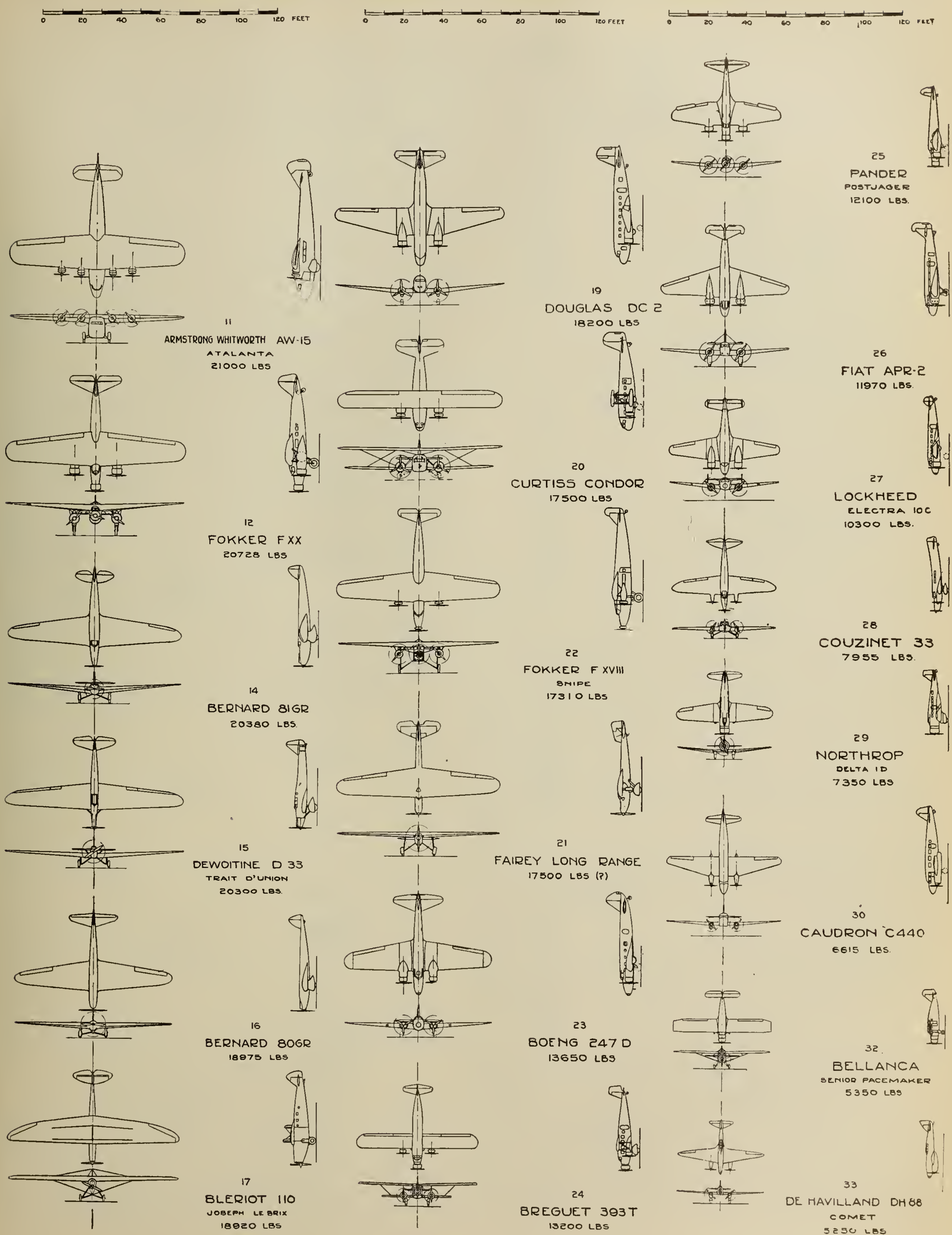
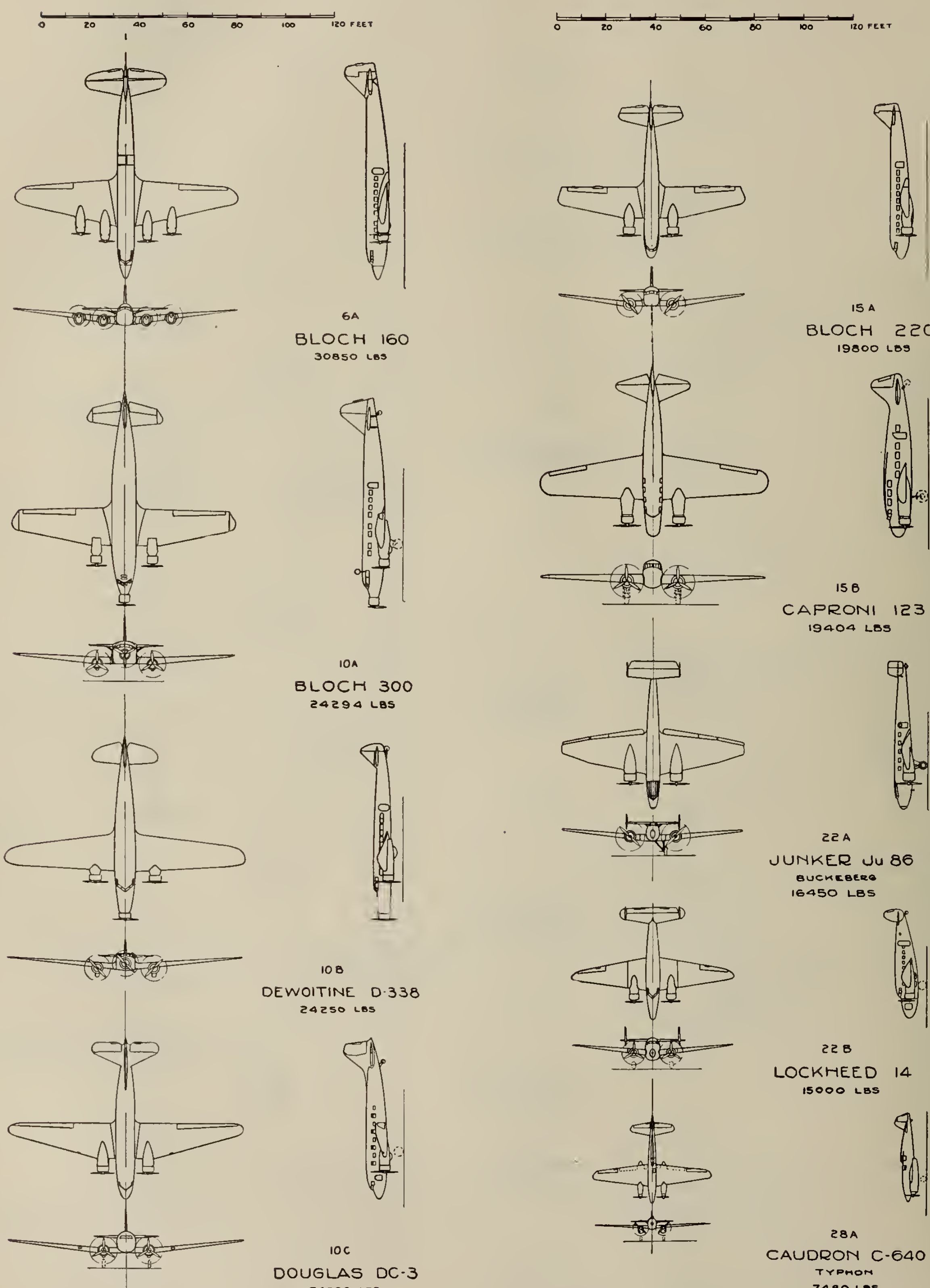

0 20 40 60 80 100 120 FEET
0 20 40 60 80 100 120 FEET
0 20 40 60 80 100 120 FEET
11
ARMSTRONG WHITWORTH AW-15
ATALANTA
21000 LBS
12
FOKKER F XX
20728 LBS
14
BERNARD 81GR
20380 LBS.
15
DEWOITINE D 33
TRAIT D'UNION
20300 LBS.
16
BERNARD 80GR
18975 LBS
17
BLERIOT 110
JOSEPH LE BRIX
18920 LBS
19
DOUGLAS DC 2
18200 LBS
20
CURTISS CONDOR
17500 LBS
22
FOKKER F XVIII
SNIPE
17310 LBS
21
FAIREY LONG RANGE
17500 LBS (?)
23
BOENG 247 D
13650 LBS
24
BREGUET 393 T
13200 LBS
25
PANDER
POSTJAGER
12100 LBS.
26
FIAT APR-2
11970 LBS.
27
LOCKHEED
ELECTRA 10C
10300 LBS.
28
COUZINET 33
7955 LBS.
29
NORTHROP
DELTA 1D
7350 LBS
30
CAUDRON C440
6615 LBS.
32
BELLANCA
SENIOR PACEMAKER
5350 LBS
33
DE HAVILLAND DH 88
COMET
5250 LBS

**Fig. 19—Aeroplanes (Civil)**



of 53,000 lb. corresponding to a wing loading of 40 lb. per sq. ft. and curves *D* (dot and dash lines) apply very roughly to an aircraft, otherwise the same, with the wing area reduced, to increase the wing loading to 40 lb. per sq. ft.

The curves illustrate the handicap on efficient operation resulting from the limitation imposed on wing loading by the requirement of safe take-off speed and the advantages that result from high wing loading. It is apparent, for instance, that, if this aircraft could be got into the air, it could fly with the wing area reduced to ½ or ⅓ of the normal area.

Roughly, for condition *C*, the cruising speed is 150 m.p.h., time of flight fifteen hours and fuel burned 15,000 lb., leaving a disposable load in excess of fuel of 11,500 lb., assuming the same weight ratio. For condition *D*, the cruising speed is 180 m.p.h., time of flight twelve hours, fuel consumed 12,000 lb. and disposable load, over and above fuel, 7,000 lb., assuming no change in structural weight. The disposable loads, less fuel, carried per horsepower, for conditions *A*, *C* and *D* are 1.8 lb., 4.1 lb., and 2.5 lb. and the transport efficiencies 0.540, 0.710 and 0.610 ton miles per hour per horsepower respectively.

The higher the wing loading, the smaller is the wing area and the size of all other elements depending thereon—tail area, length of fuselage, etc., and the smaller and lighter the aircraft. Thus, increasing wing loading reduces structural weight thereby improving the transport efficiency.

Increase in wing loading reduces the ceiling and rate of climb. For long range oversea operation from large well located permanent airports or protected harbours, a high rate of climb is not essential. The adverse effect on take-off resulting from reduced rate of climb can be nullified by catapulting and reduction in ceiling can be compensated for by supercharging the engines.

For service over the North Atlantic, good airworthiness is a prime requisite. The higher the wing loading, the less the effect of a vertical gust or squall. Highly loaded aircraft now in service confirm theory in that their flight is smooth and easy and their control characteristics in stormy weather are good. In addition, the smaller wing permitted with high loading is advantageous in flying boats when afloat.

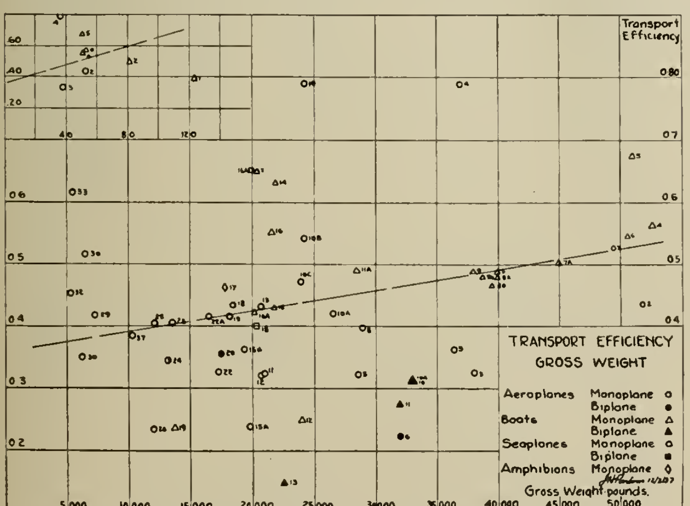



**Fig. 20—Transport Efficiency—Gross Weight**

Thus, with high wing loading, the maximum and cruising speeds are higher, range and pay load are increased, weight of structure is reduced and efficiency of transport, airworthiness and safety are improved. The accompanying loss in ceiling can be compensated, the lower rate of climb can be accepted and the increase in take-off and landing speeds can be counteracted. For these reasons, the aircraft for the transatlantic service should be designed with a high

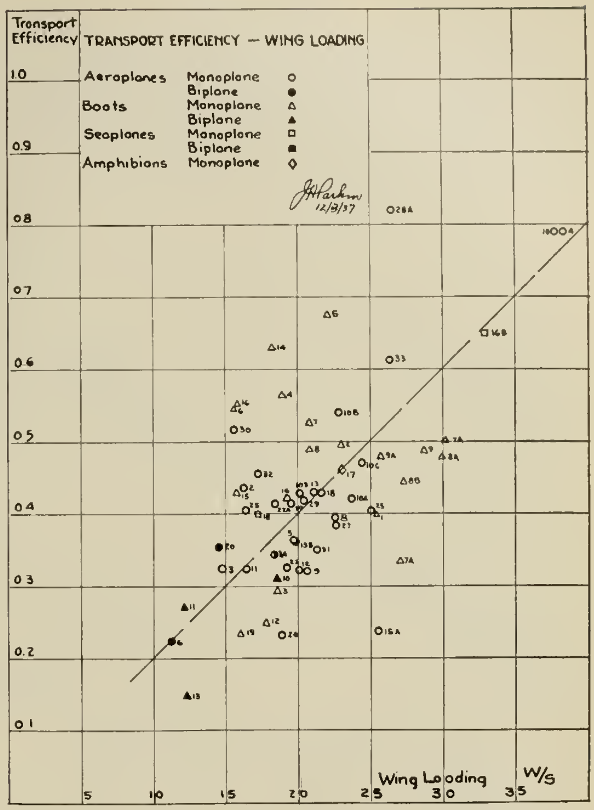



**Fig. 21—Transport Efficiency—Wing Loading.**

wing loading and a loading of 40 to 50 lb. per sq. ft. is suggested.

### Power Loading

The performance characteristics influenced by the power loading are speed, maximum and cruising, take-off, climb and ceiling. For commercial operation, the first two are usually the determining considerations. With an assisted take-off, the power loading will depend on the cruising speed and altitude and the aerodynamic fineness of the aircraft.

The graphs of Fig. 24 indicate the way in which speed is increased by increase in power and reduction of drag, and Fig. 23 illustrates the variation of speed with power loading.

The higher the power, the greater the weight of the power plant (engine, accessories and fuel) and the smaller the pay load. At the same time, the installed power must provide for operation at a cruising power below rated power and a margin of power to take care of failure of one or more engines.

With a high cruising speed, fixed by the service timetable, if the power loading is to be reasonably high and economy of operation attained, the drag of the aircraft must be reduced to a minimum.

### Aerodynamic Fineness

An analysis of the factors contributing to the total drag of an aircraft indicates that, for economy at high speeds, the wing loading must be high and the parasite drag low.

The aerodynamic cleanness of an aircraft is largely bound up with the structural design and it is necessary from an economic standpoint to balance structure weight against drag. An increase in weight must be accompanied by an increase in *L/D*. Very generally a reduction in drag is more effective in this respect than reduction in weight of structure.

The cantilever monoplane permits the cleanest aerodynamic design and, as already seen, the gain in this respect is not offset by an increase in structural weight.

Similarly, the lower drag of liquid cooled engines must be balanced against their somewhat greater weight. From this point of view, the housing of the engines wholly within the wings is desirable.

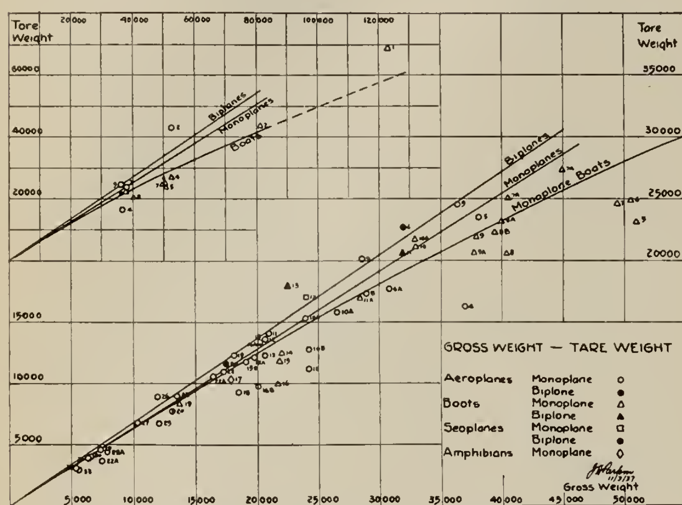



**Fig. 22—Gross Weight—Tare Weight.**

Retractable undercarriages, flush riveting of metal skins and similar means for the reduction of drag should all be employed.

While there is still room for improvement in aerodynamic cleanness, modern commercial aircraft, both aeroplanes and flying boats, possess very high values of $L/D$, ranging from 12-15. Notable performance and high transport efficiency have been attained with some of the aircraft listed in the tables, largely as a result of careful attention to aerodynamic cleanliness.

### Structure Weight

The greater the ratio of gross to tare weight, i.e., the lower the structure weight, the larger the fuel and pay load which may be carried. Reduction of the weight of the structure involves both the type of construction and the size of the aircraft and, at the same time, the drag. With certain types of construction, low structure weight is associated with high drag. As already seen, high wing loading leads to a reduction in weight.

The weights of Tables V-VII are plotted in Fig. 22, excluding those of machines specially designed to establish records and it will be seen that there is some indication, particularly for flying boats, that the structure weight is proportionately less the larger the aircraft. There may be a limit to this condition, but it is not yet evident.

### Power Plant Efficiency

Since range varies inversely as the fuel consumption, maximum range and economy result from the minimum consumption per brake horsepower per hour. This specific fuel consumption depends on a number of factors, including—

1. The power plant, its type, condition, operation and control.
2. The speed of flight.
3. The altitude of flight.

*Type of Power Plant*

Economy of transportation is influenced by the power plant, not only as a result of its effect on the specific fuel consumption, but also, since the power plant contributes a large part of the aircraft weight, through its influence on the gross weight of the aircraft. For economy, a power plant of low specific weight and low specific consumption, i.e., low weight of engine and fuel, is required.

The ratio of the fuel load to pay load varies with the length of the flight. The longer the flight, the less the pay load that can be carried. Fuel load and pay load are, in a sense, interchangeable within a given total disposable load.

At the present time, the electrical ignition gasoline engine, either air or liquid (or steam) cooled is used, with a few notable exceptions, for aircraft propulsion. Gasoline engines, developing up to 1,000 hp. and more, weighing less than 1.5 lb. per hp. and having specific consumptions of fuel and oil of 0.50-0.55 lb. per hp., are in regular production. At the same time, these engines are daily proving themselves possessed of adequate reliability, long life and low maintenance.

The present high state of development has resulted from improvements in design, in materials, in production methods and in fuels. Increased speed of rotation, higher compression ratios and supercharging have raised the output per litre of the cylinders of normal engines to 30-40 hp.

Although the specific consumption of fuel and oil of the liquid-cooled motor is slightly less than that of the corresponding air-cooled (averaging 0.52 as compared with 0.54 lb. per hp. per hr. and is still lower with glycol cooling), its specific weight, including the cooling system, is higher—2.0 lb. per hp.—compared with 1.5 lb. per hp. However, its true weight handicap is less than these figures indicate, if due allowance is made for the weight of the cowling, baffles, additional oil-cooling, etc., so necessary in modern high power air-cooled engines. On a basis of the total weight of the power plant, including fuel and oil, using the foregoing figures and neglecting the effects of differences in aerodynamic resistance, a flight of about twenty-five hours is required before the liquid-cooled motor overcomes its weight handicap. Actually, for the reasons given, a shorter time will be necessary.

While the difference in drag between the modern cowled radial air-cooled engine and an in-line liquid or steam cooled engine, with its radiator or condenser, is

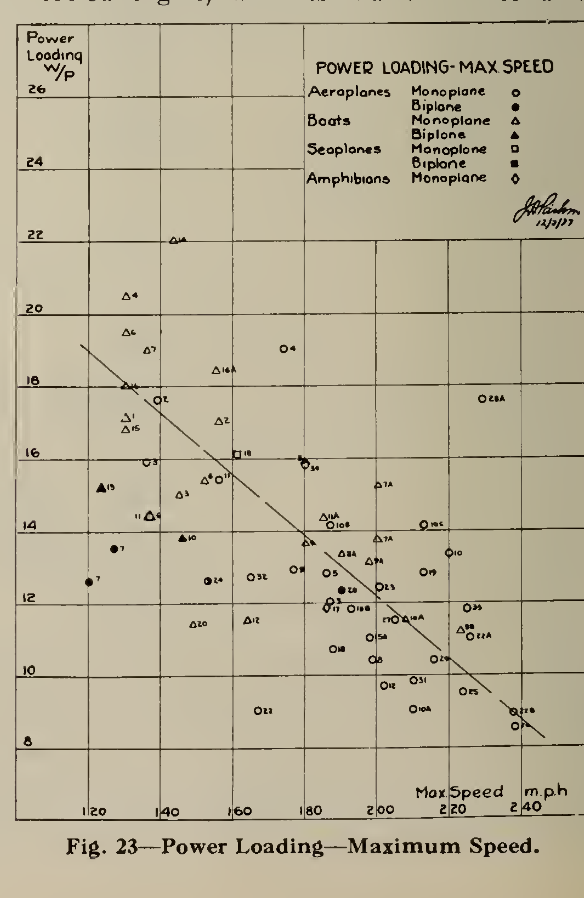



**Fig. 23—Power Loading—Maximum Speed.**

less than formerly, the advantage still rests with the liquid-cooled plant.

The former handicap of the liquid-cooled installation of lack of reliability due to "plumbing" troubles no longer exists, with the modern simplified cooling system; the air-cooled motor is acquiring an analogous handicap in the intricate system of adjustable cowling, intercylinder baffles and special oil cooling, without which high output cannot be maintained and is, at the same time, losing its former advantage of simplicity.

It is significant that, insofar as is known, all long distance world records have been made by aircraft powered by liquid-cooled motors.

For the initial transatlantic service, it is probable that the air-cooled engine will be used, but it is believed that, before the service has been long in operation, aircraft will be used in which the power plant will be housed in the wings or body, using, if air-cooled, forced air circulation through ducts. For such an installation, the radial air-cooled engine is not suitable. If liquid-cooled motors are used, ducted radiators will be employed. In either case, reduced drag and increased accessibility will result and the cooling medium, or air, heated therefrom, in the case of liquid-cooled motors, will be used for cabin heating and ice prevention.

It is further anticipated that the limitation imposed by the exhaust valve on any further large increase in specific output of the poppet valve engine, coupled with other advantages being demonstrated by this motor, will result in the rapid introduction and wide use for commercial service, particularly of the kind under consideration, of the sleeve valve motor. The low fuel consumption (i.e. 0.43 lb. per hp. per hr. at cruising power, recorded for the Bristol Perseus engine), is an important advantage of the sleeve valve motor for long range commercial service.

For commercial service, the compression ignition engine, because of its numerous advantages, is attractive and especially so for a service over long non-stop stages where its low specific consumption is able to offset its present handicap of high specific weight.

Comparison of the principal aviation compression ignition engines with modern electric ignition gasoline engines of 800-1,000 hp. yields the average figures for specific consumption and weight given in Table VIII. An allowance is made of 0.4 lb. per hp. for the weight of the cooling system of liquid-cooled gasoline engines and 0.3 lb. for that of compression ignition engines. The weight of the tankage is taken as 0.8 per cent of the fuel weight.

The weight of the complete plant for a flight of $X$ hours, neglecting effects of reduction in gross weight as fuel is consumed, is shown in the last column. From these figures, it will be seen that the compression ignition engine weighs less than the gasoline engine for flights of more than six to seven hours and possibly less if allowance is made for the better maintenance of power at height of the compression ignition engine. For a 1,000 hp. aircraft

Table VIII

Comparison of Gasoline and Compression Ignition Engines

| Type of engine | Specific weight on nominal B.h.p. — Dry | Specific weight on nominal B.h.p. — With cooling system | Specific consumption on nominal B.h.p. — Fuel and oil | Weight of power plant complete with fuel for $X$ hours |
|---|---|---|---|---|
| Air-cooled | | | | |
| Gasoline | 1.5 | | 0.54 | $1.5 + 0.58X$ |
| Compression ignition | 2.5 | | 0.40 | $2.5 + 0.43X$ |
| Liquid-cooled | | | | |
| Gasoline | 1.6 | 2.0 | 0.52 | $2.0 + 0.56X$ |
| Compression ignition | 2.6 | 2.9 | 0.38 | $2.9 + 0.41X$ |

on a flight of twelve hours, the compression ignition engine will permit, on the foregoing basis, an increase in pay load of 800-900 lb. over that with a gasoline engnie.

In view of the foregoing, it is difficult to understand the apparent lack of interest in the compression ignition engine. If the same effort had been given to the compression ignition engine as has been devoted to the development of the gasoline engine, the superiority of the compression

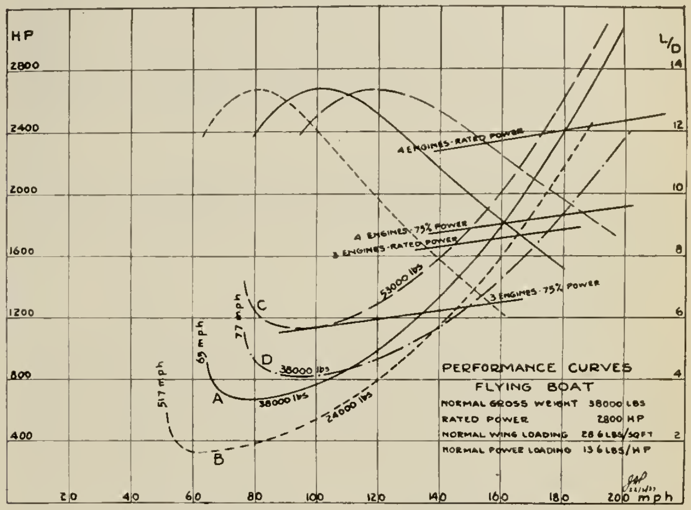



**Fig. 24—Performance Curves, Flying Boat.**

ignition engine for commercial service would be more marked. While compression ignition engines will not likely be used on the initial transatlantic services, except that of the D.L.H., it is considered that their ultimate use for this work is inevitable.

*Power Plant Operation and Control*

Overall economy of operation depends, not only on fuel consumption, but also indirectly on the life of the engine and frequency of overhauls. Aircraft engines will not run indefinitely at full power without damage. The longer and more frequent the periods of high power operation, the more frequent the overhauls. It is therefore customary to cruise with the engine throttled to from 60-75 per cent of full power to prolong its life, lengthen the periods between overhauls and afford a margin of power for use in the event of failure of one or more engines in a multi-engined aircraft. The engine is tuned for minimum specific consumption at this reduced cruising power.

It should be noted that this reduction in power can be secured at full throttle through the equivalent throttling resulting from the reduced density at high altitudes, with, at the same time, a gain in speed. Thus, at full throttle, at constant r.p.m. at 13,000 ft., the power is reduced to 60 per cent and at 8,000 ft., to 75 per cent of rated power.

The specific consumption varies with mixture, throttle and altitude. Consumption can be appreciably reduced by operating on lean mixtures, but it is normally not possible to operate on a mixture much leaner than the theoretically correct. However, engines can be safely operated on mixtures leaner than is customary, especially when throttled, and liquid-cooled motors can, in general, be operated on leaner mixtures than air-cooled.

The specific consumption varies but little with throttle in the region of the minimum, but increases appreciably for full throttle and at small throttle openings.

The more economical the operation of an engine, the less is economy affected by height. Under present conditions, there is possibly a slight gain in economy at altitudes in normally aspirated engines and also in supercharged engines up to some altitude below the rated height.

Theoretically, the reduction in consumption is about 2 per cent for normally aspirated engines and 3 to 4 per cent for supercharged engines at 15,000 ft., but this gain is largely offset by the less favourable carburation and distribution conditions at altitude.

As with manual control, fuel consumption may vary as much as 40 per cent for different pilots under the same conditions, automatic controls are now employed where economy is important. The average figures for consumption used in Table VIII would be somewhat lower with automatic controls or with unusually careful manual control. Actual consumptions in the neighbourhood of 0.4 lb. per hp. per hr. at ⅔ power have been obtained in long distance flights with liquid-cooled motors and a figure of 0.37 is theoretically possible.

Automatic controls and constant speed airscrews are used on the Sikorsky S-42 flying boats and specific consumptions as low as 0.42 lb. per hp. per hr. are reported for the Pacific flights.

*Supercharging*

The drop in power with altitude in a normally aspirated engine (power at 13,000 ft. about 60 per cent of that at sea level) is offset by supercharging. The supercharger maintains the air supplied to the engine at constant pressure (rated boost) up to the limiting or rated altitude beyond which the pressure falls with altitude in the normal way. A rated altitude of 15,000 ft. is generally considered to be about the limit for a single stage centrifugal supercharger (1.85:1 compression ratio).

While the power required to drive the supercharger increases (7.5 per cent at 12,500 ft.) and the thermal efficiency of the engine decreases, there is an actual increase of about 1 per cent per 1,000 ft. in the power developed by a supercharged engine at constant boost and r.p.m. up to rated altitude due to reduction in exhaust back pressure. At the same time, the fuel consumption is increased and the engine weight is greater by the weight of the supercharger.

The alternative to supercharging is the provision of an oversize engine such that the reduced power developed at altitude equals that required. The weight of the engine with supercharger is probably less than that of the oversize engine, but its fuel economy is also lower. On the whole, the power necessary for high speed operation at altitude can be best attained by supercharging. In addition, supercharging enables extra power to be developed at sea level to assist take-off.

For operation of the Atlantic service, cruising at 180 m.p.h. at an altitude of about 12,000 ft., as suggested later, it is considered that moderately supercharged engines of rated altitude of 5,000-6,000 ft. should be used. The throttling effect of reduction in air density above this height will reduce the power at full throttle to a cruising power of about 75 per cent of full power.

*Variable Pitch Airscrews*

For the conditions of high speed, high loading and high altitude suggested for the service, V.P. airscrews are necessary, especially with geared and supercharged engines. The primary consideration for the service is efficient operation at cruising speed and altitude. With fixed pitch airscrews designed for this condition, the loss in efficiency and power at low speeds during take-off and climb is prohibitive. With the V.P. airscrew on the other hand, the pitch can be adjusted to suit both take-off and high speed conditions. The engine therefore holds its speed and power and a large increase in thrust for take-off, 100 per cent or more in average thrust, is provided with V.P. airscrews, particularly with geared and supercharged engines.

The V.P. airscrew permits the engine speed to be controlled by the pitch of the blades as well as by the throttle and, in fact, the most recent development is the constant speed airscrew which, if left alone, maintains constant speed, although the speed may be controlled by the pilot.

Thus, operating at high altitude and full throttle, the normal cruising power results and the engine speed can be held to cruising r.p.m. by the V.P. airscrew, thereby increasing cruising speed.

In the event of engine failure in a multi-engined aircraft, the drag of the idle airscrew can be reduced and the speed and power of the active engine maintained, thereby enabling flight to be continued even with heavy load. This feature is particularly marked in the case of tandem engines. Tests indicate that fuel consumption at a given speed is less with V.P. airscrews than with an equivalent fixed pitch airscrew.

Evidently the V.P. airscrew is advantageous for the high loading, high speed and other conditions of an Atlantic air service.

### Speed

The speed of flight is determined by two principal considerations, economy of operation and the requirements of the service.

The chief advantage possessed by the aeroplane compared with the fast liner and airship for transatlantic service is speed and, if this advantage is to be appreciable, the elapsed time between terminals must be low and the cruising speed consequently high.

The schedule already suggested is based on a cruising speed of not less than 180 m.p.h.

As previously indicated, for high cruising speed, clean aerodynamic design must be combined with one or more of high wing loading, high power and high altitude of flight. The possibilities and limitations of these alternatives have already been briefly reviewed.

Ordinarily, the most economical speed is too low for practical commercial operation. Also, as fuel is consumed during flight, the weight of the aircraft decreases and the speed of maximum efficiency decreases in proportion to the square root of the gross weight, necessitating a progressive decrease in r.p.m., further throttling and increase in specific consumption. On the other hand, the most efficient speed increases with altitude and the effect of decreasing weight can be offset by increasing altitude to maintain constant speed.

To minimize the adverse effects of winds on the flying schedule, the speed must also be high since the higher the speed, the less the effect of winds.[25] This is clear from the following expression for the effective speed or speed made good. For a flight speed of $V$ and a wind speed $v$ m.p.h., at an angle $\theta$ to the course, the effective speed is:

$$V_e = \sqrt{V^2 - v^2 \sin^2 \theta} + v \cos \theta$$

Aside from schedule requirements, a high flight speed is advantageous against a head wind by reducing the time during which the handicap is suffered while, with a favouring wind, the desirable speed is one near that for minimum power, permitting the aircraft to benefit a longer time. The most economical speed is increased by head winds and decreased by tail winds.

Under the foregoing limitations, maximum practical economy is attained by adopting as high a wing loading as permissible and designing and adjusting the engine-airscrew combination to operate with minimum fuel consumption at the speed demanded by the service.

### Altitude of Flight

In the selection of the altitude of flight to be used in the service, there must be considered, economy (i.e.,

[25] In this respect also, ease of navigation is increased.

altitude for most miles per gallon), navigation and weather, personnel and passengers and other factors.

Flying at the altitude of maximum aerodynamic efficiency, the true airspeed and horsepower must be increased, at altitude, to compensate for the decrease in air density. The increase is inversely proportional to the square root of the air density, neglecting the effects of slip stream variation. The effect of altitude on the speed of maximum efficiency is similar to that of wing loading, the increase in the speed at 10,000 ft. being about equal to an increase of 1/3 in loading.

At constant $L/D$, i.e., constant indicated airspeed, economy of flight is dependent only on the specific fuel consumption. The effect, if any, of altitude will be that due to the variation of consumption with height and consumption may decrease slightly with altitude.

On the other hand, to maintain a given true airspeed at altitude (higher than that of maximum aerodynamic efficiency), the power necessary is less than at sea level since the power required depends on the drag, which, in turn, varies inversely as the $L/D$ and, as the incidence must be increased to compensate for decrease in air density, the $L/D$ increases as the angle of maximum $L/D$ is approached. Under these conditions, the power required decreases rather more rapidly than the air density. The air speed will remain nearly constant if the altitude is increased, as the weight decreases with consumption of fuel, to maintain a balance between cruising power of the engine and the power required.

From the standpoint of economy then, the service should be operated at a high altitude.

Lacking definite knowledge concerning upper air weather conditions over the Atlantic, such as the height of storms, it is not possible to predict the best altitude from a meteorological standpoint.

Experience indicates that the air pressure in the cabin must be increased over that outside if passengers are to be carried at altitudes above 12-14,000 ft.

On the whole, it is considered that, with the present state of development of aircraft and equipment, the most favourable altitude of flight for the initial transatlantic service will be about 12,000 ft., for which satisfactory and relatively light superchargers are now developed, at which special provision for the crew (and passengers) is not necessary and which probably exceeds the height of most storms.

### Precautions against Icing

The danger due to the formation of ice is peculiar to aircraft and is, perhaps, the most serious meteorological hazard of the transatlantic air service. The extent and seriousness of the hazard is as yet unknown. It has already been reported by stunt pilots and, with little doubt, has been responsible for the failure of many attempted transatlantic flights.

Ice may form on aircraft in any weather and in any cloud in which the temperature is below freezing. The character and effects of ice formation on aircraft and the conditions favourable to icing are dealt with in Appendix XII.

It is fortunate that serious deposits occur only in some form of visible moisture since the pilot is thereby given visual warning provided he knows the air temperature. The aircraft therefore should be equipped with a distant reading thermometer with metal shield and located outside the zone of influence of the airscrew; and with lights for the detection of visible moisture at night.

*Avoidance*

The best safeguard against the ice hazard is avoidance of the ice-forming region through accurate meteorological prediction of the location and extent of the region. The number and complexity of the factors involved in icing, the difficulty of observation and consequent lack of information renders prediction in particular for the transatlantic service very difficult.

Heaviest icing usually occurs in long extended zones associated with "fronts," i.e., air mass boundaries. Synoptic maps give information concerning such fronts. This is another reason for the provision of the most complete weather maps and forecasts possible for each flight.

The most dangerous condition occurs in low cold air, when warm air meets and over-rides a stationary low flat air mass, or a wedge of cold air pushes under a warm air mass. The former is the condition of a change from frost to thawing weather and the latter from mild to cold. Icing due to supercooled rain is less common in the latter case.

Temperature is the principal criterion of the probability of icing. Lacking upper air information, the air temperatures at altitude must be estimated from surface conditions, assuming a suitable lapse rate. The latter depends on many factors: time of day, season, latitude, surface (land or water) cloudiness, wind, pressure distribution and precipitation. It averages 1 deg. per 328 ft.

Determination from the ground of the size of cloud droplets, which has a bearing on the kind of ice formed, is difficult. An incipient rain condition indicates large droplets. A corona, if small, i.e., close to sun or moon, indicates large droplets. A halo indicates clouds composed of ice spicules.

Low pressure areas being generally associated with cloudiness and precipitation, are usually more favourable to icing conditions than are high pressure areas. Conditions favourable to icing are probable to the leeward of large bodies of water and over high terrain.

When very damp cloud air at subfreezing temperatures is encountered and icing is probable, as a result of cold air inflow or over-running, an attempt should be made to climb above the clouds. This is often successful at heights of 10-13,000 ft., although, in most cases, an altitude of 16,000 ft. is required and even this may not be sufficient. While climbing, the zone of frost should be avoided to escape icing and possible reduction in ceiling of the aircraft.

Ice deposits from freezing rain can often be removed or prevented by flying in the inversion usually existing above such rains.

If ice forming fronts must be crossed, it should be done at right angles, to shorten the period of icing.

*Prevention*

While avoidance of the ice forming zone, through meteorological prediction, is the best safeguard, with existing knowledge, such prediction is uncertain. Preventive measures on the aircraft are therefore necessary to cope with unexpected, heavy and rapid icing. Also, the extent of the zone and the service schedule may be both such as to necessitate flight through the zone.

Many preventive methods and devices have been suggested or tried. Very few have been found reasonably efficacious and have been adopted in service.

The use of coatings of so-called waterproof materials, such as oil, grease and wax, to lower the adhesion of ice has been found ineffective. Resistance to penetration of water at ordinary temperatures is no indication of resistance to ice at or below freezing, in fact, the reverse may be the case.

The adhesion of ice can be definitely lowered, although the rate of formation is little affected, by providing on the surface, a substance which, mixed with supercooled water, lowers the freezing point sufficiently to maintain a liquid boundary layer. Because of their more rapid rate of mixing, liquids miscible in all proportions with water are superior to soluble solids for this purpose, but they must be protected from the scrubbing action of the air and rain. Specially processed rubber and leather have been found the best means of retaining the liquids on the surface.

In the so-called "overshoe" developed in the United States, the coating of specially processed rubber has built into it, for wings, three air tubes and for tail surfaces a single tube weaving back and forth. The overshoe is held to the leading edge of metal wings by means of threaded rivets. Air at 5 pounds pressure is supplied to the tubes through distributing valves in such a way that the tubes are alternately inflated and deflated about every 40 seconds, thereby first cracking the ice, then lifting it so that it is caught by the air and carried away, owing to the reduced adhesion.

The complete installation weighs about 75 lb. There is negligible effect on performance except when the tubes are inflated. The rubber is said to require renewal about once a year. Originally, the rubber was impregnated with pine oil, but the oil has been found unnecessary. The overshoe is widely used on commercial aircraft in the United States and Europe.

In the "anticer" develped at the Royal Aircraft Establishment in England, a porous outer surface of specially tanned leather is employed, to which ethylene glycol alone or mixed with 10 per cent of ethyl alcohol is fed under slight pressure through a perforated tube. The liquid is spread by an under layer of cotton and saturates the leather. As fast as the ice is formed, that next the leather is melted by the liquid, lowering the adhesion and the ice is blown off by the air. The flow of fluid may be varied to suit conditions and is normally about 1½ pints per hour. The anticer is applied to the leading edges of wings and tail surfaces. It is light, easily fitted and has little effect on performance. It has been found effective in service.

Airscrews may be protected in a similar way by means of a porous leather cover over the boss and inner portion of the blades to which the glycol is fed by means of a slinger ring on the back of the hub.

A somewhat similar arrangement has been developed in the United States. The airscrew is fitted with an oil impregnated rubber covered spinner. An 95:15 alcohol glycerine mixture is fed by means of a slinger ring to tubes which deliver the liquid, behind the spinner, to the leading edge of each blade and the liquid spreads over the blade under the combined action of centrifugal force and air flow. The increased centrifugal force, combined with a certain amount of flexing and heat generated in overcoming viscous drag, tend to keep the blade tips free of ice.

In addition to icing under conditions already mentioned, ice formation in the carburettor and induction system, due to cooling caused by evaporation of the fuel, may have serious consequences. Carburettor icing depends on the humidity, temperature and pressure. In an unheated carburettor, dangerous accumulations are probable with high humidity for intake air temperature between 15 and 65 deg. F. It may be prevented by heating the intake air or, more effectively, by heating the carburettor by jacketing. Another effective method is by the addition of alcohol (ethanol and methanol) to the fuel in the carburettor, under the control of an ice detector, which admits alcohol when ice begins to form.

Freezing of radiator shutters is best prevented by placing them back of the radiator.

Airspeed heads are now commonly protected from ice by electric heating. Venturis are replaced by vacuum pumps and windmill drives by positive drives from the engine.

The use of heat for ice prevention is attractive. The large amount of waste heat available (about ⅔ that in the fuel), the fact, proved in hydro-electric plant practice, that the temperature of the surface need be only a minute fraction of a degree above freezing to prevent the adhesion of ice, and the further fact that icing most frequently occurs with temperatures close to the freezing point, are factors favourable to the use of heat.

The amount of heat required will depend upon the meteorological conditions, the wing and the speed. The rate of heat transmission through the brass covering of a Clark Y wing, at 80 m.p.h., has been found to vary from 27 near the leading edge to 19 B.t.u. per sq. ft. per hr. per deg. F. temperature difference near the trailing edge.

Utilization of waste heat from the power plant is considered practicable only for all metal monoplanes. There are a number of promising possibilities.

With liquid cooled (glycol) or steam cooled engines, the jacket heat may be used in wing and tail surface radiators, or possibly leading edge radiators. The reduced drag of the radiators may be more than offset by the greater weight and plumbing difficulties.

The piping of the exhaust gases to a detachable leading edge is perhaps the most direct method of utilizing the heat in the exhaust, but difficulties are involved, including corrosion due to acids and high temperatures, thermal expansion and proximity to wing fuel tanks. The probable reduction in exhaust noise is an advantage of the method.

There is some indication from tests that heating the leading edge is effective only in preventing the accumulation of ice in that region, and that ice will continue to form on the unheated after portion of the wing.

It has been suggested in the National Research Laboratories, Ottawa, that icing of the wings and of the airscrew might be prevented by piping exhaust gases to a leading edge section of the wing and discharging them therefrom through a properly located narrow slot parallel to the span in such a way that a sheet of hot gases flows back over the wing surface. The blades of pusher airscrews sweeping through this sheet of hot gases may have their temperature raised sufficiently, in combination with the temperature increase due to viscous drag, to prevent ice formation.

Rough preliminary tests of such an arrangement made early in 1935 in the National Research Laboratories gave promising results. The wing surface from leading to trailing edge was kept ice free.

National Advisory Committee for Aeronautics tests have indicated that a pusher propeller, driven by an extension shaft from an engine housed in the wing is a more efficient combination than any radial engine driven tractor or pusher airscrew combination tested. There may be additional advantages, both aerodynamic and to the engine, in the discharge of exhaust gases in the manner suggested.

Experience with stainless steel silencers for aircraft engines indicates that the use of stainless steel overcomes corrosion troubles. Stainless steel is now being introduced for aircraft construction.

The driving of an airscrew by means of an extension shaft has been proved feasible by the long service of such drives in the Junker G-38. More recently, military aircraft have been built in which this form of drive is employed.[26]

In addition to other advantages, propulsion of aircraft by means of airscrews, driven through extension shafts from engines housed in the wings, is a convenient arrangement for the prevention of ice by utilization of waste heat. For the method suggested, using a slotted nose section, the connections would be very direct. It makes possible the utilization of heated air from air-cooled engines, or from ducted radiators and condensers in liquid or steam-cooled engines, alone or in combination with air heated by the exhaust.

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[26]The Westland F7-30 and Koolhoven FK-55.

### Instrument Equipment

The success of the transatlantic air service will depend very largely upon the piloting and navigation, and the aircraft must therefore be provided with the best and most comprehensive of instrument equipment.

For a long range service of this kind, an automatic pilot is essential. This instrument automatically maintains the aircraft on a pre-set course and in a given trim, thereby increasing the accuracy of course keeping and of control, improving control in bad weather or conditions of low visibility, reducing the risk of loss of control under such conditions and reducing the strain on and fatigue of the pilot.

The automatic pilot includes two indicating instruments which serve also with manual control, namely the gyro horizon and the directional gyro. It is desirable, however, to provide duplicates of these as a precautionary measure.

In addition to the instruments included in the automatic pilot, essential instruments for blind flying, which may be used in different combinations, include the gyro turn indicator, ball or pendulum type cross level or side slip indicator, rate of climb indicator, or fore and aft level, airspeed indicator and sensitive altimeter.

For navigation, in addition to the foregoing, there should be provided at least two magnetic compasses, one of which may be arranged to control the directional gyro, drift and ground speed indicator, course and distance calculators, chronometer, astronomical instruments such as bubble sextant, radio compass and other radio direction finding equipment to which reference has already been made.

The need for the most complete engine instrument equipment for this service, where proper functioning of the power plant is so important, need not be emphasized. Fuel-air indicators and fuel flow meters should be included.

For catapulting, provision of a fore and aft accelerometer is desirable.

For the detection of icing conditions and ice, a distant reading thermometer and suitable lights are necessary.

### Summary

To summarize the foregoing, the suggested aircraft for the initial transatlantic service should be one designed for the carriage of mail and express, having a pay load capacity of 1,500-2,000 lb., a cruising speed of 180 m.p.h., a range of 2,400 miles against a headwind of 30 m.p.h. and fitted for catapult launching at a speed of 100 m.p.h. The type, either flying boat, amphibian or wheeled aeroplane, will be determined by the terminal conditions. The aircraft should be a monoplane and, if a boat or amphibian, a high wing monoplane. If a wheeled aeroplane, it should be fitted with a retractable undercarriage and provided with ample flotation in the form of water-tight compartments and wings. Provision should be made for landing on snow or ice.

The wing loading should be high—40-50 lb. per sq. ft.—the aerodynamic design clean and the structure weight carefully controlled to permit a weight ratio of not less than 2:1. The aircraft should be multi-engined, with, initially, air-cooled gasoline engines, moderately supercharged to 5,000-6,000 ft., equipped with automatic controls, and fitted with variable pitch or constant speed airscrews. Early consideration should be given to liquid cooled and sleeve valve engines and especially to compression ignition engines.

The aircraft should be fitted with lift-increasing devices to reduce the landing speed after a ten-hour flight to 60-65 m.p.h., with wheelbrakes and with dump valves in the fuel tanks.

Full provision should be made for the detection and prevention of icing.

The instrument equipment should include automatic pilot and complete blind flying, navigation and engine instruments.

### Conclusion

Determined efforts are about to be made to establish a commercial air service by aeroplane across the North Atlantic and thereby surmount one of the last of the great barriers to the linking of the continents by air transport.

In this paper, an attempt has been made to review the different aspects of the problem, the various considerations involved and to outline the organization, in a general way, of a commercial transatlantic air service.

The successful establishment of a transatlantic air service between London and Montreal will mark another achievement in the progress of transportation and one in which Canada will continue her close association of the past with new developments in transportation.

### Acknowledgments

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## APPENDIX I

### North Atlantic Air Crossings*

(A) Non-Stop

| No. | Date | Pilot | Route | Aircraft | Time | Miles |
|---|---|---|---|---|---|---|
| | 1919 | | | | | |
| 1 | June 14 | Alcock and Brown | St. Johns-Clifden | Vickers Vimy | 16-12-00 | 1,890 |
| 2 | July 2- 6 | Scott and 28 | East Fortune-Garden City, N.Y. | HMA-R-34 | 108-12-00 | 3,270 |
| 3 | July 9-12 | Scott and 28 | Garden City-Pulham | HMA-R-34 | 75-00-00 | |
| | 1924 | | | | | |
| 4 | Oct. 12-15 | Eckener and 31 | Friedrichshafen, Basle, Bordeaux, Azores, Grand Banks, Cape Race, Long Island, Lakehurst, N.J. | ZR-3 (Los Angeles) | 81-17-00 | 4,010 |
| | 1927 | | | | | |
| 5 | May 20-21 | Lindbergh | New York-Paris | Ryan | 33-29-30 | 3,620 |
| 6 | June 4- 5 | Chamberlin and Levine | New York-Eisleben, Germany | Bellanca | 42-00-00 | 3,930 |
| 7 | June 29-July 1 | Byrd and 3 | New York-Var-sur-Mer | Fokker | 43-30-00 | 3,490 |
| 8 | Aug. 27-28 | Brock and Schlee | Harbour Grace-Croydon | Stinson | 23-21-00 | 2,350 |
| | 1928 | | | | | |
| 9 | Apr. 12-13 | Huenefeld and 2 | Baldonnel (Dublin)-Greenly Island (Lab.) | Junker L-33 | 37-00-00 | 2,070 |
| 10 | June 17-18 | Stultz and 2 | Trepassy Bay-Burry Port, Eng. | Fokker VII | 20-40-00 | 4,449 |
| 11 | Oct. 11-15 | Eckener, 38 and 19 pass. | Friedrichsbafen, Gibraltar, Madeira, Azores, Bermuda, Virginia coast, Lakehurst | Graf Zeppelin | 111 38-00 | 6,160 |
| 12 | Oct. 29-Nov. 1 | Eckener, 39 and 20 pass. | Lakehurst-Friedrichshafen (slightly south of great circle) | Graf Zeppelin | 75-33-00 | |
| | 1929 | | | | | |
| 13 | June 13-14 | Assolant and 3 | Old Orchard, Me.-Commillas, Spain | Bernard | 29-52-00 | 3,000 |
| 14 | July 8 | Williams and Yancey | Old Orchard, Me.-Santander, Spain | Bellanca | 31-30-00 | |
| 15 | Aug. 1- 4 | Eckener, 41 and 19 pass. | Friedrichshafen-Lakehurst | Graf Zeppelin | 93-23-00 | |
| 16 | Aug. 8-10 | Eckener and ? | Lakehurst-Friedrichshafen | Graf Zeppelin | 55-00-00 | |
| 17 | Sept. 1-14 | Lebmann, 41 and 17 pass. | Lakehurst-Friedrichsbafen (Round world cruise) | Graf Zeppelin | 66-00-00 | |
| | 1930 | | | | | |
| 18 | June 23-24 | Kingsford Smitb and 3 | Port Marnock, Ireland-Harbour Grace | Fokker VII | 30-28-00 | |
| 19 | July 29-Aug. 1 | Booth and 43 | Cardington-Montreal | HMA-R-100 | 78-52-00 | |
| 20 | Aug. 14-16 | Booth and 43 | Montreal-Cardington | HMA-R-100 | 56-12-00 | |
| 21 | Sept. 1- 2 | Costes and Bellonte | Paris-New York | Brequet | 37-17-00 | 3,610 |
| 22 | Oct. 9-10 | Boyd and Conner | Harbour Grace-Tresco, Scilly Islands | Bellanca | 23-44-00 | 2,260 |
| | 1931 | | | | | |
| 23 | June 23-24 | Post and Gatty | Harbour Grace-Chester, Eng. | Lockbeed Vega | | |
| 24 | June 24-25 | Hoiriis and Hillig | Harbour Grace-Krefeld, Germany | Bellanca | 32-00-00 | |
| 25 | July 15-16 | Endres and Magyar | Harbour Grace-Bickse (Budapest) | Lockbeed Sirius | 26-12-00 | |
| 26 | July 28-29 | Boardman and Polando | New York-Istanbul, Turkey | Bellanca | | |
| 27 | July 28-29 | Herndon and Pangborn | New York-Moylgrove, Wales | Bellanca | 32-00-00 | |
| | 1932 | | | | | |
| 28 | May 21 | Earhart | Harbour Grace-Culmore, Ireland | Lockbeed Vega | 15-40-00 | 2,026 |
| 29 | July 5- 6 | Mattern and Griffin | Harbour Grace-Berlin | Lockheed | 18-40-00 | |
| 30 | Aug. 21 | Mollison | Portmarnock, I.F.S.-Pennfield Ridge, N.B. | Puss Motb | 30-12-00 | |
| | 1933 | | | | | |
| 31 | June 3- 5 | Mattern | New York-Moscow | Lockbeed | 32-00-00 | 4,920 |
| 32 | July 15-16 | Post | Brooklyn, N.Y.-Berlin | Lockheed | 25-48-00 | 3,942 |
| 33 | July 15-17 | Darius and Girenas | Brooklyn, N.Y.-Soldin, Germany | Bellanca | crashed | |
| 34 | July 22-23 | Capt. and Mrs. Mollison | Pendine Sands, Wales-Stratford, Conn. | DeH Dragon | | |
| 35 | Aug. 5- 7 | Codos and Rossi | Brooklyn-Rayak, Syria | Bleriot | | 5,656 |
| 36 | Nov. 1- | Eckener, crew and 22 pass. | Chicago, Akron, Seville, Friedrichshafen | Graf Zeppelin | | |
| | 1934 | | | | | |
| 37 | May 14-15 | Pond and Sabelli | Brooklyn-Lahinch, I.F.S. | Bellanca | 32-00-00 ? | |
| 38 | May 28 | Codos and Rossi | Paris-Brooklyn | Bleriot | 38-30-00 | 3,280 |
| 39 | July 1 | Adamowicz Bros. | Harbour Grace-Flens de Lorne, France | Bellanca | | |
| 40 | Aug. 9 | Ayling and Reid | Wasaga Beach, Ont.-Middlesex, Eng. | DeH Dragon | 30-51-00 | 3,500 |
| | 1935 | | | | | |
| 41 | Sept. 21-22 | Waitkus | Brooklyn-Ballenrobe, I.F.S. | Lockbeed Vega | 23-15-00 | |
| | 1936 | | | | | |
| 42 | May 6 | Eckener, 54 and 50 pass. | Friedrichshafen-Lakeburst (northern route) | LZ 129 Hindenburg | 61-40-00 | 4,407 |
| 43 | May 11 | Eckener, 54 and 53 pass. | Lakehurst-Friedrichsbafen (over north of England) | LZ 129 Hindenburg | 49-45-00 | 4,089 |
| 44 | May 16 | Crew 54, pass. 41 | ? -Lakehurst | LZ 129 Hindenburg | 78-29-00 | 4,453 |
| 45 | May 20 | Crew 54, pass. 57 | Lakehurst- ? | LZ 129 Hindenburg | 48-08-00 | 4,044 |
| 46 | June 19 | Eckener, 53, pass. 42 | Frankfurt-am-Main-Lakeburst | LZ 129 Hindenburg | 61-20-00 | 4,194 |
| 47 | June 23 | Crew 54, pass. 56 | Lakeburst-Frankfurt (crossed England) | LZ 129 Hindenburg | 61-10-00 | 3,980 |
| 48 | June 30 | Crew 55, pass. 21 | Frankfurt-Lakeburst (via St. Lawrence valley) | LZ 129 Hindenburg | 52-48-00 | 4,166 |
| 49 | July 3 | Crew 55, pass. 54 | Lakehurst-Frankfurt | LZ 129 Hindenburg | 45-39-00 | 3,917 |
| 50 | July 10 | Crew 53, pass. 50 | Frankfurt-Lakeburst (via Azores) | LZ 129 Hindenburg | 63-37-00 | 4,179 |
| 51 | July 14 | Crew 53, pass. 56 | Lakeburst-Frankfurt | LZ 129 Hindenburg | 60-58-00 | 4,451 |
| 52 | Aug. 5 | Lebman, 56, pass. 50 | Frankfurt-Lakeburst | Lz 129 Hindenburg | 75-26-00 | 4,966 |
| 53 | Aug. 9 | Lebman, 56, pass. 54 | Lakeburst-Frankfurt | LZ 129 Hindenburg | 42-52-00 | 4,127 |
| 54 | Aug. 15 | Crew 58, pass. 58 | Frankfurt-Lakeburst | LZ 129 Hindenburg | 71-00-00 | 4,694 |
| 55 | Aug. 19 | Crew 58, pass. 58 | Lakehurst-Frankfurt | LZ 129 Hindenburg | 43-48-00 | 4,012 |
| 56 | Sept. 17 | Crew 59, pass. 72 | Frankfurt-Lakehurst | LZ 129 Hindenburg | 62-55-00 | 4,107 |
| 57 | Sept. 21 | Crew 59, pass. 59 | Lakehurst-Frankfurt | LZ 129 Hindenburg | 55-36-00 | 4,121 |
| 58 | Sept. 26 | Crew 57, pass. 44 | Frankfurt-Lakehurst | LZ 129 Hindenburg | 63-12-00 | 4,236 |
| 59 | Sept. 30 | Crew 57, pass. 41 | Lakeburst-Frankfurt | LZ 129 Hindenburg | 58-25-00 | 4,078 |
| 60 | Oct. 5 | Crew 60, pass. 53 | Frankfurt-Lakeburst | LZ 129 Hindenburg | 55-25-00 | 4,112 |
| 61 | Oct. 3 | Crew 60, pass. 49 | Lakeburst-Frankfurt (crossed England) | LZ 129 Hindenburg | 52-30-00 | ? |
| 62 | Sept. 2-3 | Merrill and Ricbman | Brooklyn-Llandilo, S. Wales | Vultee V-1a | 18-38-00 | 3,300 |
| 63 | Sept. 4 | Mrs. Markham | Abingdon-Baleine Cove, N.S. | Percival Vega Gull | 25-10-00 | 2,700 |
| 64 | Sept. 14 | Merrill and Richman | Southport-Musgrave Harbour, Nfld. | Vultee | 15-17-00 | 2,300 |
| 65 | Oct. 30 | Mollison | Harbour Grace-Croydon | Bellanca | 13-17-10 | 2,100 |

*Up to December 31st, 1936. (While the list is thought to be reasonably complete and accurate, tbere may be omissions and errors.)
Particulars regarding the Hindenburg kindly supplied by F. W. von Meister, Special U.S. Representative of Deutsche Zeppelin Reederei and Luftscbiffbau Zeppelin.

## APPENDIX I—(Continued)

(B) By Stages

| No. | Date | Pilot | Route | Aircraft | Time | Miles |
|---|---|---|---|---|---|---|
| | 1919 | | | | | |
| 1 | May 16-31 | Read and 5 | Trepassy Bay-Azores-Lisbon | NC-4 | | 2,437 |
| | 1924 | | | | | |
| 2 | July 17-Sept. 6 | Smith, Arnold, Nelson and Harding | Brough-Kirkwall-Hornafjord-Reykjavik-Frederiksdal-Ivigtut-Ice Tickle Bay (Lab.) | Douglas | 39-23-00 | 2,850 |
| 3 | July 17-Sept. 6 | | (Aug. 31)—Hawkes Bay, Nfld., Pictou, N.S., Casco Bay, Boston. (Round world flight) | Douglas | | |
| | 1927 | | | | | |
| 4 | May 23-June 13 | Pinedo and 2 | Trepassy-160 miles off Azores-St. Michaels-Lisbon | Savoia | | |
| | 1930 | | | | | |
| 5 | Aug. 19-26 | Gronau and 3 | Warnemünde-Faroes-Reykjavik-Ivigtut-Cartwright-Queensport-Halifax-New York | Wal | 47-00-00 | |
| | 1931 | | | | | |
| 6 | Aug. 7-17 | Gronau and 3 | List—Faroe Islands-Reykjavik-Scoresby Sound-Sukkertoppen-Godthaab-Port Harrison-Long Lac-Chicago | Wal | | |
| | 1932 | | | | | |
| 7 | May 21-22 | Christiansen and 14 | Holyrood-Conception Bay-Azores-Vigo-Calshot | DO-X | 28-55 00 | 2,310 |
| 8 | July 22-27 | Gronau and 3 | List-Seydisfjord-Reykjavik-Ivigtut-Cartwright-Montreal | Wal | | |
| | 1933 | | | | | |
| 9 | July 1-14 | Balbo and 96 | Orbitello-Amsterdam-Londonderry-Reykjavik-Cartwright-Shediac, N.B.-Montreal-Chicago | 24 Savoia S 55 X | | |
| 10 | July 22-Aug 26 | Colonel and Mrs. Lindbergh | Long Island-Cartwright-Hopedale-Godthaab-Angmagsalik-Reykjavik-Ivaerad (Faroe)-Lerwick (Shetland)-Copenhagen | Sirius | | |
| 11 | July 25-Aug. 14 | Balbo and 96 | Brooklyn-Shediac-Shoal Harbour-Azores-Lisbon-Ostra (Rome) | 24 Savoia S 55 X | 48-47-00 | 6,065 |
| | 1934 | | | | | |
| 12 | July 20-Aug. 30 | Grierson | London-Londonderry-Reykjavik-Angmagsalik-Godthaab-Lake Harbour-Povungnituk-East Main-Ottawa | Fox Moth | | 4,000 |
| | 1936 | | | | | |
| 13 | Sept. 5-10 | Blankenburg and 3 | Lisbon-Punta Delgada-Azores (Schwabenland)-Port Washington, N.Y. | DO18 Zephyr | 22-14-00 | 2,390 |
| 14 | Sept. 5-12 | Engel and 3 | Lisbon-Punta Delgada-Azores (Schwabenland)-Bermuda-Port Washington, N.Y. | DO18 Aeolus | 24-19-00 | 2,833 |
| 15 | Sept. 22-23 | Engel and 3 | Port Washington (Schwabenland)-Azores | Aeolus | 17-50-00 | 2,400 |
| 16 | Sept. 24 | Blankenburg and 3 | Port Washington-Bermuda (Schwabenland)-Azores | Zephyr | ? | ? |
| 17 | Oct. 7 | Blankenburg and 3 | Azores (Schwabenland)-Port Washington, N.Y. | Zephyr | 18-20-00 | |
| 18 | ? | Engel and 3 | Azores (Schwabenland)-Port Washington, N.Y. | Aeolus | ? | |
| 19 | Oct. 17 | Engel and 3 | Sydney, N.S. (Schwabenland)-Azores | Aeolus | ? | 1,800? |
| 20 | Oct. 18 | Blankenburg and 3 | Sydney, N.S. (Schwabenland)-Azores | Zephyr | ? | 1,800? |

*Up to December 31st, 1936. (While the list is thought to be reasonably complete and accurate, there may be omissions and errors.)

## APPENDIX II

### Canadian Ship-Shore Air Mail Services

1. *Record of Montreal-Rimouski Summer Service**

| Year | Single trips: Scheduled | Single trips: Completed | Mail carried (pounds) |
|---|---|---|---|
| 1927 | | 10 | 2,469 |
| 1928 | | 94 | 62,834 |
| 1929 | 124 | 114 | 68,672 |
| 1930 | 92 | 72 | 54,044 |
| 1931 | 97 | 87 | 54,801 |
| 1932 | 83 | 69 | 38,987 |
| 1933 | 66 | 54 | 33,253 |
| 1934 | 59 | 50 | 31,546 |
| 1935 | 63 | 60 | 39,390 |
| 1936 | 63 | 54 | 42,676 |

2. *Record of Montreal-Moncton Winter Service**

| Year | Route | Single trips: Scheduled | Single trips: Completed | Mail carried (pounds) |
|---|---|---|---|---|
| 1929 | Montreal-Saint John | 66 | 56 | 4,279 |
| 1930 | Montreal-Moncton | 504 | 358 | 7,256 |
| 1931 | Montreal-Moncton | 206 | 169 | 2,775 |

3. *Schedule of Red Bay-Ottawa Service, 1932*

London—leave 2.00 p.m.—by aeroplane to Cherbourg.
Cherbourg—leave 6.30 p.m.—by *Empress of Britain*.
Strait of Belle Isle—2.30 a.m., third day out—transferred by naval tender.
Red Bay-Havre St. Pierre—by seaplane, 386 miles, 4 hours.
Havre St. Pierre-Rimouski—by flying boat, 290 miles, 3½ hours.
Rimouski-St. Hubert (Montreal)—by aeroplane, 314 miles, 3½ hours, arrive 4.00 p.m.—mail sorted.
Montreal-Ottawa—by aeroplane, 110 miles, 1 hour, arrive 5.30 p.m.
1,100 miles flown in 12 hours' flying time and 15 hours' elapsed time.

*Figures kindly furnished and checked by Mr. G. Herring, Chief Superintendent, Air and Land Mail Services.

## APPENDIX III

### Ship-Shore Catapult Equipment

(A) *Ile de France Installation.*

Catapult—compressed air operated
overall length 111 ft. 7 in.
weight 60 tons
launching capacity 4 tons at 112 m.p.h.

Aircraft— Liore and Olivier amphibian
weight 7,275 lb.
speed 105 m.p.h.
range 7 hours at 90 m.p.h.

later— CAMS—37 amphibian

(B) *Bremen and Europa Installations.*

Catapult—Heinkel K-2
compressed air operated—air pressure 28-78 atmospheres, depending on the wind speed
accelerating distance 65.6 ft.
braking distance 9.84 ft.
weight including catapult, circular rail and pivot and excluding understructure and compressor installation—260 tons
launching capacity 4 tons at 62.2 m.p.h.

Aircraft—Bremen—Heinkel He-12—low wing seaplane
weight empty 3,454 lb., loaded 5,100 lb.
later Junker Ju 46 with extra tanks
range 11 hours at 112 m.p.h. cruising speed
Europa—Heinkel He-58.

## APPENDIX IV

### Record of N.D.L. Bremen-Europa Ship-Shore Service

Westbound*—To New York

| Year | Flights | Flying time | | | Distance | | | Bags and parcels | Weight pounds |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Aver. | Min. | Max. | Aver. | | |
| 1929 | 3 | | | | | | 106 | | |
| 1930 | 11 | | | | | | 263 | | |
| 1931 | 14 | 00:44 | 17:00 | 6:12 | 60 | 1,340 | 513 | 4 | |
| 1932 | 18 | 00:20 | 11:25 | 5:54 | 20 | 830 | 478 | 4 | 36.3 |
| 1933 | 17 | 00:45 | 9:35 | 6:26 | 70 | 735 | 554 | 7 | 44.1 |
| 1934 | 18 | 3:13 | 10:20 | 7:32 | 248 | 856 | 694 | 6 | 60.3 |
| 1935 | 17 | 2:32 | 11:24 | 8:17 | 224 | 901 | 693 | 7 | 120.5 |

Eastbound—To Southampton and Bremershaven

| Year | Flights | Distance Aver. |
|---|---|---|
| 1929 | 4 | 342 |
| 1930 | 11 | 923 |
| 1931 | 14 | 1,026 |
| 1932 | 17 | 1,094 |
| 1933 | 17 | 1,108 |
| 1934 | 18 | 1,310 |
| 1935 | ? | ? |

*Information kindly furnished by the Hamburg-America Line and North German Lloyd.

## APPENDIX V

### Transatlantic Traffic

Europe-North America

Passenger

| | Westbound | Eastbound |
|---|---|---|
| *Canadian Ports* (1) | | |
| Calendar year 1936 | | |
| Quebec | 12,064 | 8,605 |
| Halifax | 5,773 | 4,150 |
| Montreal | 41,295 | 45,781 |
| Total | 59,132 | 58,536 |
| *United States Ports* (2) | | |
| Calendar year 1935 | | |
| Northern—First | 21,848 | 21,842 |
| Cabin | 21,483 | 20,659 |
| Total | 157,356 | 164,851 |
| Southern—First | 16,910 | 16,136 |
| Cabin | 9,551 | 8,563 |
| Total | 92,241 | 73,205 |
| Total— First | 38,758 | 37,978 |
| Cabin | 31,034 | 29,222 |
| Total | 249,597 | 238,055 |
| von Hindenburg 1936 (3) | 481 | 537 |

Mail

| | | |
|---|---|---|
| *Canadian Ports* (4) | | |
| Calendar year 1936 | | Pounds |
| First class | | 759,000 |
| Prints, etc. | | 2,394,000 |
| Parcel | | 523,000 |
| Total | | 3,676,000 |
| *United States Ports* (5) | | |
| Year ending June 30th, 1936 | | |
| U.S. Letters | | 2,517,605 |
| Prints | | 13,537,543 |
| Parcels | | 10,800,377 |
| Foreign Letters | | 273,088 |
| Prints | | 889,234 |
| Parcels | | 14,118 |
| Total | | 28,031,765 |
| via von Hindenburg (1936) | 4,892 (260,379 pieces) | 4,556 (195,964 pieces) |

Freight (cargo tons of 2,240 lb.)

| | Westbound | Eastbound |
|---|---|---|
| *Canadian Ports* (6) | | |
| Year ending March 31st, 1936 | 3,453,000 | 7,108,374 |
| *United States Ports* (2) | | |
| Calendar year 1935 | | |
| Ports in North Atlantic District | | |
| From and to | | |
| United Kingdom | 803,385 | 1,115,904 |
| North Atlantic and Baltic Europe | 1,479,615 | 415,659 |
| Havre-Hamburg Range | 1,244,164 | 1,386,361 |
| South Atlantic Europe | 473,355 | 202,203 |
| West Mediterranean | 380,967 | 786,923 |

(1) Information kindly furnished by National Harbours Board, Dept. of Transport, Canada.

(2) Information kindly furnished by United States Maritime Commission.

(3) Information kindly furnished by Mr. F. W. von Meister.

(4) Information kindly furnished by Post Office Department, Ottawa.

(5) Information kindly furnished by United States Post Office Department.

(6) Information kindly furnished by Dominion Bureau of Statistics.

## APPENDIX VI

### Fog—North American Coast

Table I—Normal Percentage of Days with Fog at Points in Newfoundland and on the Gulf of St. Lawrence

Information supplied by the Director, Meteorological Service of Canada.

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Aver. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| St. Johns, Newfoundland | 4 | 5 | 6 | 17 | 17 | 9 | 15 | 12 | 9 | 7 | 9 | 3 | 9 |
| Belle Isle | 7 | 5 | 13 | 29 | 39 | 42 | 55 | 41 | 27 | 24 | 15 | 4 | 25 |
| Yarmouth | 4 | 4 | 5 | 9 | 11 | 16 | 30 | 26 | 15 | 9 | 2 | 4 | 11 |
| Saint John, N.B. | 7 | 10 | 7 | 11 | 15 | 27 | 34 | 34 | 19 | 14 | 8 | 7 | 16 |
| Bird Rocks | 6 | 6 | 10 | 18 | 27 | 29 | 28 | 12 | 11 | 11 | 9 | 5 | 14 |
| Charlottetown | 1 | 1 | 3 | 3 | 1 | −1 | −1 | 0 | 1 | 1 | 2 | 1 | 1 |
| Father Point | 0 | 0 | 1 | 3 | 3 | 6 | 9 | 6 | 4 | 4 | 0 | 0 | 3 |
| Quebec | 3 | 3 | 3 | 3 | 3 | 1 | 0 | 3 | 6 | 5 | 4 | 3 | 3 |

Table II (*a*)—Percentage of Days with Fog at Lighthouses on the Newfoundland Coast

From "Fog at Sea," W. E. Hurd, U.S. Weather Bureau Pilot Chart of Upper Air—North Atlantic Ocean, December 1936 (Data supplied by Inspector of Lighthouses, Newfoundland)

| Lighthouse | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Aver. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *North-East Coast* | | | | | | | | | | | | | |
| Notre Dame Bay— | | | | | | | | | | | | | |
| Gull Is. (1900-11 inc.) | 3 | 10 | 10 | 16 | 21 | 27 | 23 | 16 | 10 | 10 | 14 | 8 | 14 |
| Nippers Harbour (1902-11 inc.) | 1 | 2 | 3 | 7 | 11 | 9 | 8 | 6 | 3 | 9 | 11 | 5 | 6 |
| Long Is. (1904-11 inc.) | 1 | 4 | 2 | 5 | 10 | 10 | 4 | 4 | 6 | 4 | 8 | 7 | 5 |
| Long Point (1900 11 inc.) | 2 | 8 | 9 | 11 | 15 | 15 | 11 | 5 | 6 | 4 | 5 | 8 | 8 |
| *East Coast—Central Portion* | | | | | | | | | | | | | |
| Catalina Harbour— | | | | | | | | | | | | | |
| Green Is. (1900-06, 08-11 inc.) | 6 | 6 | 7 | 11 | 11 | 14 | 22 | 11 | 8 | 7 | 12 | 5 | 10 |
| *East Coast—Southern Portion* | | | | | | | | | | | | | |
| Conception Bay— | | | | | | | | | | | | | |
| Cape St. Francis (1900-11 inc.) | 6 | 12 | 10 | 17 | 19 | 19 | 19 | 11 | 9 | 10 | 13 | 10 | 13 |
| Near Cape Spear— | | | | | | | | | | | | | |
| St. Johns' Harbour (1900-7, 9-11 inc.) | 19 | 14 | 14 | 27 | 27 | 34 | 34 | 24 | 17 | 20 | 18 | 14 | 22 |
| *South Coast, near extreme Eastern Portion* | | | | | | | | | | | | | |
| Trepassey Bay— | | | | | | | | | | | | | |
| Powell's Head (1903-07 inc.) | 6 | 4 | 4 | 15 | 13 | 16 | 32 | 12 | 1 | 6 | 8 | 6 | 10 |
| *South Coast, near extreme Western Portion* | | | | | | | | | | | | | |
| Channel Head (1900-07 inc.) | 5 | 3 | 4 | 15 | 13 | 16 | 31 | 17 | 11 | 8 | 2 | 4 | 11 |
| *West Coast* | | | | | | | | | | | | | |
| Bay St. George— | | | | | | | | | | | | | |
| Sandy Point (1900-8, 10-11) | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 1 |
| Bay of Islands— | | | | | | | | | | | | | |
| Frenchman Head (1902-8, 10) | 0 | 0 | 1 | 5 | 14 | 11 | 11 | 6 | 5 | 5 | 3 | 1 | 5 |
| Bonne Bay— | | | | | | | | | | | | | |
| Lobster Cove Head (1900-10) | 0 | 0 | 1 | 3 | 5 | 7 | 14 | 6 | 2 | 3 | 1 | 1 | 4 |
| Keppel Harbour— | | | | | | | | | | | | | |
| Keppel Island (1901-10) | 0 | 0 | 0 | 1 | 4 | 5 | 13 | 6 | 2 | 2 | 1 | 1 | 3 |

Table II (*b*)—Percentage of Days with Fog at North American Stations

12-16 years' record

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Aver. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belle Isle | 13 | 18 | 19 | 18 | 30 | 44 | 63 | 49 | 38 | 32 | 24 | 7 | 30 |
| Father Point | ½ | ½ | 2 | 3 | 4 | 9 | 8 | 8 | 6 | 4 | ½ | ½ | 4 |
| St. Johns | 11 | 10 | 12 | 14 | 20 | 18 | 12 | 10 | 8 | 12 | 11 | 8 | 12 |
| Sydney | 5 | 5 | 6 | 11 | 10 | 7 | 6 | 5 | 5 | 5 | 9 | 7 | 7 |
| Halifax | 6 | 5 | 6 | 9 | 14 | 11 | 15 | 9 | 6 | 5 | 5 | 3 | 8 |
| Quebec | 2 | 1½ | 1 | 3 | ½ | ½ | 1 | 1 | 3 | 5 | 4 | 2 | 2 |
| Montreal | 3 | 2 | 2 | 2 | ½ | 0 | 0 | 0 | 2 | 5 | 3 | 2 | 2 |
| New York | | | | | | 3 | | | | | | 10 | |
| Norfolk | | | | | | 3 | | | | | | 6 | |

## APPENDIX VII

### Depot Ships of the Deutsche Luft Hansa

In organizing its air mail service to South America, the Deutsche Luft Hansa adopted depot ships as the most satisfactory solution of the problem of operating the service across the South Atlantic under the conditions. The conditions confronting the D.L.H. included lack of aircraft capable of making the crossing non-stop with sufficient payload, lack of colonies and hence sites for bases and lack of airports with adequate facilities to permit the use of large heavily loaded landplanes.

Possessing in the Dornier Wal an efficient and seaworthy, long range flying boat, capable, almost fully loaded, of alighting and remaining afloat for days in South Atlantic weather and of taking off unaided from sheltered water, the use of depot ships enabled the D.L.H. to start the service without waiting for larger aircraft able to make the 1,890-mile ocean flight from Bathurst, Gambia to Natal, Brazil, non-stop.

Following successful trial flights to and from the depot ship *Westfalen*, stationed in mid-ocean, in November 1933, a regular fortnightly service (each way) was commenced February 4th, 1934, and a weekly service in September 1934. The service has been operated, with a high degree of regularity since that time, largely with Dornier Wals improved in 1934, driven by two-geared BMW-VIu motors and having a range of 1,680 miles, cruising at 120 m.p.h., the all-up weight being 22,000 lb. The first night flight was made October 23rd, 1934.*

In April 1934, the 5,500 miles from Pernambuco, Brazil, to Stuttgart were flown in two days, twenty-three hours, forty-five minutes. The average overall time from Stuttgart to Rio is fifty-five to fifty hours.

The mail load, each way, was originally 150 to 175 lb. (about 20,000 letters) and is now 450 to 500 lb., the capacity being 880 lb.

The German air mail letter rate is 1.50 and 1.25 marks for 5 grammes (1.6 oz.) to Buenos Aires and Rio de Janeiro respectively.

Up to the end of 1936, over 200 ocean flights had been made and more than 10,000,000 letters carried, with the loss of one aircraft only.

The D.L.H. now has three depot ships in service, the *Westfalen*, a converted Norddeutscher Lloyd cargo ship, the *Schwabenland*, formerly a cargo and passenger ship of the Dampfschiffahrts Gesselschaft Hansa and the *Ostmark*, a specially built motor ship placed in service in 1936. Particulars of these ships are given in the accompanying table.

The depot ships are fitted with the following equipment: a compressed air operated catapult for launching the flying boats; a rotating and folding electric crane for lifting the flying boats on deck or on the catapult; a trailing apron or "strausegel" to facilitate hoisting the aircraft aboard in rough weather; complete radio and meteorological equipment; accommodation for aircraft on deck to permit servicing and repairs.

The apron, invented by Herr Hein, is of sailcloth some 100 ft. long, with bamboo spreaders and drag pockets on the under side. It trails from a roller at the stern of the ship and, when not in use, is rolled up. When the aircraft alights, the ship reduces way, the apron submerges and the aircraft taxies on it. The ship then speeds up, the canvas becomes taut and raises the aircraft almost entirely out of the water. A secure connection between ship and aircraft is thus provided so that, even in a heavy sea, the aircraft can be lifted inboard by the crane without risk.

The *Westfalen* and *Schwabenland* each have two short wave transmitters (800 watts for distant ground station and 60 watts for aircraft), one medium wave transmitter (key and voice, 300-3,000 m.), duplicate receivers and loop aerial for direction finding.

The aircraft are equipped with 20 watt medium and short wave transmitters and receivers and loop aerial. The normal range of the loop aerial is 600 nautical miles and occasionally up to 900 miles.

The *Ostmark* is equipped with four standard transmitters and six receivers for long and short waves, including an emergency spark transmitter and a radiogoniometer.

The ships are also equipped as meteorological and oceanographic stations, staffed by the Deutsche Seewarte. Weather reports are received from each other, from ships at sea, and from land stations, particularly upper air pilot balloon observations from West African stations. Balloon observations are also made from the ships. Weather maps and forecasts are prepared in each ship for each flight.

Originally, the D.L.H. employed the depot ship primarily as a refueling station. The old 7-ton Wals were unable to fly non-stop across the South Atlantic. The flying boat flew to the depot ship, stationed in mid-ocean, and alighted on the sea. The mail was transferred to a second aircraft, already prepared on the catapult, which was then launched and continued the crossing while the first was hoisted aboard, refueled and made ready to continue the next crossing. Alternatively, on reaching the depot ship, the aircraft was hoisted aboard, refueled and launched to complete the crossing.

With the improved 10-ton Wals, having range sufficient for the whole flight from Africa to Brazil, there was no need for mid-ocean refueling and the depot ships have functioned as launching stations. As such, stationed in sheltered water, and with improved crane arrangements, the need for the trailing apron has largely disappeared. With two depot ships, one is stationed at Bathurst, the second at Fernando de Noronha. At Bathurst, the mail is placed on the aircraft on the ship; the latter leaves port and the aircraft is launched. On reaching the second ship, if enough fuel is left, the aircraft continues to Natal, otherwise it alights and is refueled. From Natal, the aircraft flies to the depot ship, is taken aboard, the ship puts to sea and some hours later the aircraft is catapulted toward Bathurst.

The Deutsche Luft Hansa apparently contemplates initiating in 1937 a North Atlantic service via the Azores and Bermuda, using the same technique which has proved so successful in the South Atlantic. The *Schwabenland* and a sister ship, now building, will be used for launching.

The oversea flight being longer, new aircraft have been built for the North Atlantic. These are the Dornier DO18 flying boats, powered by tandem Junker Jumo 500/560 Diesel engines and designed for the carriage of mail and express over long distances after catapulting, and the Ha139 twin float monoplanes for catapulting, built by the Hamburger Flugzeugbau, weighing 11½ tons, with four Jumo motors and having a top speed of 186 m.p.h. and a range of 3,100 miles.

During September and October 1936, the *Schwabenland*, the largest of the three ships, was used in trial flights across the North Atlantic by two DO18 flying boats, to study flying conditions, equipment, navigation and landing facilities. In these trials, the depot ship functioned as a launching station. Two flights each way were made. First launched westward at the Azores, the two aircraft flew to New York, one non-stop (2,390 miles) and the other via Bermuda (2,063 miles) where it was again catapulted. The *Schwabenland*, having followed to New York, the aircraft were catapulted for the eastward flight via Bermuda to the Azores. The second westward crossing was made non-stop to New York. The aircraft then flew to Sydney, N.S., were launched from the ship and flew to the Azores.

The flights were reported successful. With the exception of a leaking radiator, during one of the first westward flights, there was no trouble and no replacements were necessary in the aircraft or motors and the flights were made, without waiting, in such weather as occurred.

As a refueling base, and for launching aircraft, the catapult equipped depot ship possesses the advantages of mobility and lower cost. If the aircraft is forced down at sea within reasonable distance, the ship can proceed to it and, in a moderate sea, using the trailing apron, the aircraft can be taken aboard. As a launching device, the mobility of the depot ship permits the base to be shifted at will. The cost of the ship is relatively low and the Diesel engined depot ship is economical to operate, due to the absence of standby losses when not under way, the readiness for immediate service and to the economy of and small space occupied by the engines.

### Deutsche Luft Hansa Depot Ships

| *Ship* | *Westfalen* | *Schwabenland* | *Ostmark* |
|---|---|---|---|
| Fitted out or built | 1932 | 1934 | 1936 |
| Type | steam | twin ? Diesel | twin Diesel |
| Gross registered tonnage | 5,124 | 8,188 | 2,000 |
| Power—hp | 2,750 | 3,600 | 1,800-2,000 |
| Speed—knots | 11.5 | 12 | 13½-15 |
| Length—ft | 410-0 | 460-0 | 245-0 |
| Beam—ft | 52-6 | | 37-6 |
| Draught—ft | 28-0 | | |
| Crew | 40 | | |
| Gasoline tankage—gals | 8,800 | 19,800 | |
| *Catapult* | | | |
| Type | Heinkel K-6 | Heinkel | Heinkel K-9 |
| Location | bow | stern | bow |
| Maximum capacity— | | | |
| Gross weight—lb | 30,860 | 30,800 | 33,000 |
| Take-off speed—m.p.h | 93 | 93 | 93 |
| Maximum acceleration | 3.5 $g$ | 3.5 $g$ | |
| Mean acceleration | 2.8 $g$ | 2.8 $g$ | |
| Length of accel. run—ft | 103-9 | 103-9 | 103-9 |
| Length of braked run—ft | 16-5 | 18-0 | 18-0 |
| Total length—ft | 138-0 | 136-0 | 136-0 |
| Width | 6-6 | 7-3 | |
| Weight of carriage—lb | | | 3,960 |
| Stroke of piston | 18-8 | | |
| Maximum pressure—atmos | 150 | 160 | 160 |
| Total weight—lb | 128,000 | 205,000 | |
| *Crane—Electric* | | | |
| Type | rotating | rotating and folding | rotating |
| Maximum load—lb | 33,000 | 33,000 | 33,000 |
| *Aircraft Accommodation* | | | |
| Number | | 3 | 1 |

*For catapulting on moonless nights, a motor drive was fitted to the artificial horizon.

## APPENDIX VIII

### Armstrong Seadromes

In the floating aerodrome as developed by Edward R. Armstrong for use as a refueling station on Atlantic air routes, the flight deck is 1,500 ft. long and 300 ft. wide amidships, and 150 ft. wide at the ends. The deck is supported some 100 ft. above sea level on 32 buoyancy units, in the form of vertical streamlined telescoping columns, the upper portions of which constitute buoyancy chambers and the lower, ballast chambers. When the seadrome is in place the cylinders are extended, the ballast sections sinking to a depth of about 200 ft. The buoyancy units are of streamline section to reduce the resistance to the passage of waves, and are so designed that the centres of buoyancy and gravity are well below the water surface. As a result, it is claimed that tank tests have shown that the seadrome is unaffected by wave motion and has no tendency to roll or pitch. It is said that theory indicates and experience in submarines confirms that wave action is hardly perceptible at a depth of 200 ft.

A second deck, below the flying platform and reached by elevator, carries hangars, workshop, radio and meteorological stations and accommodation for crew and passengers.

The decks and buoyancy units are interconnected by lattice beams to form a rigid structural unit weighing some 28,000 tons. The displacement with full ballast tanks will be about 67,000 tons.

The difficulty of mooring the seadrome under Atlantic conditions is believed to have been overcome. The conditions designed for are: depths of 3-4 miles, 70 mile wind, and 1½ knot current, the latter imposing a cable tension of some 200,000 lb.

The mushroom shaped 1,650 ton anchor will be floated to position, buoyancy chambers will then be flooded and the rate of descent of the anchor checked by canvas drogues.

The anchor will be connected to a triangular buoy of the same type of construction as the seadrome, by means of two suspension bridge type steel cables connected through chains to the anchor.

The triangular anchor buoy will carry beacon light and radio equipment.

The seadrome is in turn connected to the buoy. To provide a further margin under extreme conditions and also for manoeuvring, four of the buoyancy units of the seadrome are fitted with electric motor driven propellers capable of developing a total thrust of 100,000 lb.

The cost of each seadrome unit is estimated to be between six and seven million dollars.

The seadrome project contemplates the stationing of seadromes at approximately 500-mile intervals between Europe and America, in one case along the 38th parallel of latitude to secure better weather conditions, or, as proposed by M. Bleriot, near the latitude of New York. The latter suggested that if initially all seadromes were not constructed, intermediate floating islands equipped as meteorological and radio stations and beacons should be provided, anchored in the same manner as the seadromes, and hence readily replaced by the latter when constructed. A somewhat similar suggestion has been made in connection with the Pacific route; that small structures, resembling the anchorage buoy of the seadromes, equipped as radio and meteorological stations, and with lifeboats and motor patrol boat to send supplies to aircraft forced down, should be provided at a cost of about $200,000 each.

The economics of the seadrome project, as outlined by M. Louis Bleriot, are:

| | |
|---|---|
| Capital cost— | |
| 4 seadromes at 110,000,000 fr. each say.......... | 500,000,000 fr. |
| Yearly revenue— | |
| *Postal* 2/7 of receipts from carriage of 500 tonnes of letters and 800 tonnes of papers and parcels to yield.......... | 90,000,000 fr. |
| *Passenger* 1/5 of receipts from fares of 80,000 passengers at 5,250 fr. each.......... | 60,000,000 fr. |
| *Other* sale of gasoline and oil, rental of hangars and stores, hotels, etc.......... | 12,000,000 fr. |
| Total say.......... | 170,000,000 fr. |
| Operating charges— | |
| Maintenance, salaries, insurance.......... | 33,000,000 fr. |
| Balance..........say | 140,000,000 fr. |

Technically the construction, anchorage and seaworthiness of the seadrome appears practicable and it is reported to have received the approval of the U.S. Navy Department and of marine engineers.

From an aeronautical standpoint experience with aircraft carriers would indicate the plan to be feasible, although the deck area may be inadequate for modern, large, high speed, commercial aircraft with high wing loading, and landing in fog would be hazardous.

A serious obstacle to the project is the uncertainty as to the territorial status of the seadrome. Is it a ship or territory—national or international? What is its status in war? Virtually it appears to be an island, well stocked with fuel and other supplies, but an island capable of being moved and hence a valuable prize.

The lower cost per pound rendered possible by the smaller fuel load for the shorter stages between seadromes is attractive. Whether this reduction in transport cost is sufficient to offset the great cost of the seadromes is doubtful. It appears that the tolls that it will be necessary to impose to make the project pay will be too high for the traffic to bear.

## APPENDIX IX

### Take-Off Conditions

The calculation of the take-off conditions of aircraft requires a detailed knowledge of the particular aircraft, including the aerodynamic characteristics of the aircraft and propeller, hydrodynamic characteristics of the hull, engine performance, condition of aerodrome, and many other factors; and even when these are reasonably well known, certain assumptions still have to be made and these, with the variation in the technique of take-off of different pilots, render close prediction difficult.

For this reason and also because a general outline only is here necessary, the following very rough figures are given to illustrate the take-off limitations.

Although not included in the following, "ground effect" is an important factor in connection with take-off. Ground effect through reducing the induced drag of the wing and the angle of attack for a given lift coefficient facilitates take-off. At the same time, a heavily loaded aircraft, having taken off, may find it impossible to climb beyond the zone of influence of ground effect which is confined to a height above the ground about equal to the span of the wings.

*Symbols*

$W$—gross weight of aircraft, lb.
$P$ —rated horse power of engines.
$D$ —air resistance of aircraft (without hull or floats in case of seaplane) without slipstream, lb.
$R$ —reaction drag—ground or water resistance, lb.
$F$ —effective accelerating force, lb.
$T$ —propeller thrust corrected for slipstream resistance, lb.
$V$ —velocity, ft. per sec.
$S$ —wing area, sq. ft.
$s$ —distance, ft.
$t$ —time, seconds.
$g$ —acceleration of gravity, ft. per sec. per sec.
$q=\frac{1}{2}\rho V^2$—dynamic pressure, lb. per sq. ft.
$\rho$ —mass density of air, slugs per cu. ft.
$\mu$ —coefficient of rolling friction.

*Subscripts*

0 —at beginning of ground run.
1 —at take-off.
$m$—mean during take-off.
$w$ —wind.

The take-off is usually analyzed in three stages, the ground run up to unstick speed, the change of flight path, through an arc to climbing attitude, and climb to clear an obstacle of given height. It will be sufficient to consider only the first stage here.

The minimum speed of flight is simply given by

$$V=\sqrt{\frac{1}{C_{L\max}\cdot\frac{\rho}{2}}}\sqrt{\frac{W}{S}}$$

The aircraft may be stalled off at minimum speed. In the case of a seaplane it may be necessary to stall off the top of a wave. Ordinarily the take-off speed may be possibly 10 per cent higher than stalling speed (which implies that the wing is operating at a $C_L$ about 20 per cent less than $C_{L\max}$), in order that some reserve of lift may be available after take-off. Minimum take-off run or time, however, usually requires that the aircraft be stalled off. As already mentioned, ground effect permits the aircraft to take off at a speed below the minimum for flight at an altitude.

An expression for the length of the ground run has been obtained by integration from the energy equation by Dr. Martin Shrenk, as follows:

$$Fds=\frac{W}{g}\,d\left(\frac{V^2}{2}\right)\quad\text{and}\quad\frac{V^2}{2}=\frac{q}{\rho}$$

$$ds=\frac{W}{\rho g}\cdot\frac{dq}{F}$$

It is assumed that the propeller thrust decreases linearly with $q$ and that the angle of attack is constant during the ground run so that the reaction drag and air resistance are proportional to $q$. Then

$$F=F_0-\frac{F_0-F_1}{q_1}\cdot q$$

and

$$ds=\frac{W}{\rho g}\,\frac{dq}{\left(F_0-\frac{F_0-F_1}{q_1}q\right)}$$

integrating, and determining constant of integration by the fact that $s=0$ when $q=0$

$$s_1=\frac{W}{\rho g}\cdot\frac{q_1}{F_0-F_1}\cdot\log\frac{F_0}{F_1}$$

A simplification can be effected by assuming, instead of a linear reduction in effective accelerating force from $F_0$ to $F_1$, that the mean accelerating force acts uniformly during take-off, then

$$F_m = \frac{F_0 + F_1}{2}$$

and

$$ds = \frac{W}{\rho g} \cdot \frac{dq}{F_m}$$

integrating

$$s_1 = \frac{W}{F_m} \cdot \frac{q_1}{\rho g} = \frac{W}{F_m} \cdot \frac{V_1^2}{2g} = \frac{W}{F_m} \cdot \frac{W}{S} \cdot \frac{1}{C_{L\max} \rho g}$$

The last formulae are in error less than 4 per cent where $F_0$ is equal to or less than twice $F_1$.

Shrenk indicates that the minimum ground run results when the run is made at an angle of attack approximately equal to that for minimum drag in flight, until the minimum flight speed is reached, when the aeroplane is pulled up to an angle corresponding to minimum flight speed and the aeroplane lifts off.

Assuming constant acceleration during take-off,

since $$s = \frac{V_1 t}{2}$$

$$t = \frac{W}{F_m} \cdot \frac{V_1}{g} = \frac{W}{F_m} \sqrt{\frac{W}{S}} \frac{\sqrt{C_{L\max} \rho}}{g\sqrt{2}}$$

*Effect of Head Wind on Take-off.*

The principal effect of a head wind is to reduce the ground speed for take-off to $V_1 - V_w$ together with a minor effect due to the resulting increase in propeller efficiency.

The take-off run is reduced to

$$s = \frac{W}{F_m} \frac{(V_1 - V_w)^2}{2g}$$

It is evident from this formula that the reduction in ground run due to a relatively light wind is appreciable. A wind of velocity equal to 10 per cent of the take-off speed reduces the ground run about 20 per cent.

The effective accelerating force is:

$$F = T - R - D$$

*Air Resistance.*

The air drag $D$ is practically the same for modern aircraft whether seaplane or landplane.

Assuming constant attitude during take-off (angle of maximum lift) which is as accurate as other assumptions that have to be made, the air resistance increases from zero to a maximum in proportion to $V^2$. The resistance at take-off will be

$$D = \frac{W}{L/D}$$

where the value of $L/D$ is that corresponding to maximum lift, which, in modern aircraft, will range from 7 to 9 depending on the cleanliness of design.

As the variation of drag with speed for constant angle is parabolic, the average air resistance during take-off will be $\frac{D}{3}$.

Taking $L/D = 8$ the average air drag is

$$D_m = \frac{W}{24} = 0.04\,W$$

*Reaction Drag.*

It is the difference between the water resistance of seaplanes and the ground resistance of landplanes that is responsible for the difference in the take-off performance of these two types of aircraft.

(a) Landplanes

The friction drag $R = \mu W_m$

$W_m$ is the load on the ground, which equals the difference between the gross weight and the air lift and decreases from $W$ to zero. As the variation of lift follows the same parabolic law as that of the drag during take-off, the average ground reaction during take-off is $\frac{2}{3} W$ and the mean reaction drag is

$$R_m = \frac{2}{3} \mu W$$

$\mu$ depends upon the nature of the take-off surface. For reasonably good conditions, say hard turf and short grass, a conservative value is $\mu = .06$.

Then $R_m = 0.04\,W$

(b) Seaplanes

The familiar form of the curve of water resistance of a hull during take-off plotted on speed has been shown by Gouge to be approximated by a parabola, the maximum hump resistance ranging from 0.16 $W$ for a good hull to 0.25 $W$ for a rather poor one.

On this basis the average water resistance during take-off will be 2/3 of the maximum or say

$$R_m = 0.10\,W$$

The water resistance of the hull includes the air drag.

*Effective Propeller Thrust.*

The thrust can be made sensibly the same for seaplane and landplane.

A reasonable assumption is that

$$T = K \cdot P$$

where the constant $K$ depends on the pitch angle and speed of the propeller and varies from 3.4 for direct drive and fixed or two pitch

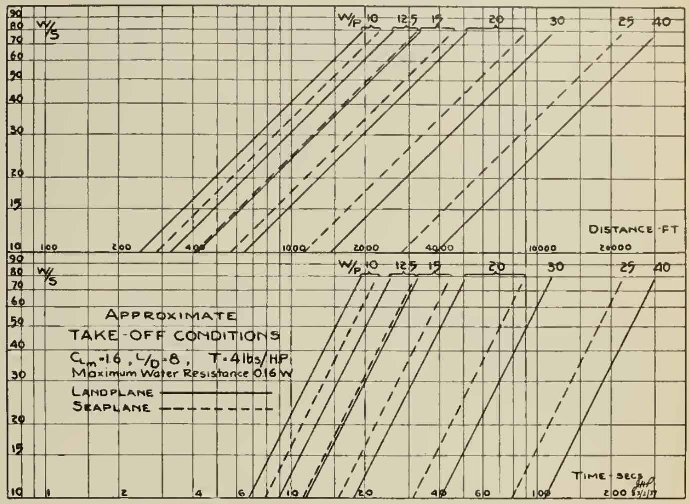


Fig. 25—Approximate Take-Off Conditions.

propellers to 4.2 for geared engines with constant speed propellers. An average value may be taken as 4.

Assume the propeller thrust constant during take-off and equal to $4\,P$.

*Average Effective Accelerating Thrust.*

(a) Landplanes

Using average values

$$\begin{aligned} F_m &= T - R - D \\ &= 4\,P - 0.04\,W - 0.04\,W \\ &= 4\,P - 0.08\,W \\ &= \left(\frac{4}{W/P} - 0.08\right) W \end{aligned}$$

and $$\frac{W}{F_m} = \frac{12\frac{W}{P}}{50 - \frac{W}{P}} \text{ roughly}$$

(b) Seaplanes

$$\begin{aligned} F_m &= 4\,P - 0.10\,W - 0.04\,W \\ &= 4\,P - 0.14\,W \\ &= \left(\frac{4}{W/P} - 0.14\right) W \end{aligned}$$

and $$\frac{W}{F_m} = \frac{7\frac{W}{P}}{30 - \frac{W}{P}}$$

It has been found that in many cases the acceleration during 2/3 or more of the take-off run is sensibly constant and hence the net accelerating force must be approximately constant.

*Finally*

For landplanes

$$s = \frac{12\frac{W}{P}}{50 - \frac{W}{P}} \cdot \frac{V_1^2}{2g} = \frac{12\frac{W}{P}}{50 - \frac{W}{P}} \cdot \frac{W}{S} \cdot \frac{1}{C_{L\max} \rho g}$$

For seaplanes

$$s = \frac{7\frac{W}{P}}{30 - \frac{W}{P}} \cdot \frac{V_1^2}{2g} = \frac{7\frac{W}{P}}{30 - \frac{W}{P}} \cdot \frac{W}{S} \cdot \frac{1}{C_{L\max} \rho g}$$

For landplanes

$$t = \frac{12\frac{W}{P}}{50 - \frac{W}{P}} \cdot \frac{V_1}{g} = \frac{12\frac{W}{P}}{50 - \frac{W}{P}} \sqrt{\frac{W}{S}} \cdot \frac{\sqrt{C_{L\max} \rho}}{g\sqrt{2}}$$

For seaplanes

$$t = \frac{7\frac{W}{P}}{30 - \frac{W}{P}} \cdot \frac{V_1}{g} = \frac{7\frac{W}{P}}{30 - \frac{W}{P}} \sqrt{\frac{W}{S}} \cdot \frac{\sqrt{C_{L\max}\rho}}{g\sqrt{2}}$$

The formulae are plotted in the accompanying Fig. 25.

For landplanes, the take-off distance is important, to reduce the size of aerodromes and runways required, while for seaplanes the take-off time is important to reduce the punishment of the hull by waves and to permit take-off from small or crowded harbours.

It is evident from the foregoing formulae that the take-off distance increases as the gross weight, as the square of the take-off speed and hence as the wing loading and with increase of power loading.

The take-off time increases as the gross weight, as the take-off speed and hence as the square root of the wing loading, and with increase of power loading.

Evidently also cleanness of both aerodynamic and hydrodynamic design improve take-off as does condition of the runway or take-off surface.

## APPENDIX X

### Fixed Long Run Shore Catapult

With the limited space available on shipboard, the accelerations are necessarily high in ship catapults. On the other hand, with relatively unlimited space available on land, the length of the track can be long and the accelerations moderate. This is illustrated by the figures in the following table, for two ship catapults and for a suggested land catapult.

| Catapult | Acceleration run | Weight of aircraft | Launching m.p.h. | Speed f.p.s. | Aver. f.p.s.$^2$ | Accel. $g$ | Time sec. | Accel. force |
|---|---|---|---|---|---|---|---|---|
| *Bremen* | 65 ft. 0 in. | 4 tons | 62.2 | 91 | 63.7 | 1.98 | 1.43 | $2W$ |
| *Ostmark* (Heinkel K9) | 103 ft. 9 in. | 15 tons | 93.0 | 136 | 89.2 | 2.77 | 1.53 | $2.8\ W$ |
| Land | 2,000 ft. 0 in. | 25 tons | 100.0 | 147 | 5.4 | 0.167 | 27.4 | $W/6$ |

Evidently, the accelerations need not be prohibitive in land catapulting. An acceleration of 0.16 $g$ is rather greater than that in an electric train, but less than that possible in a motor car.

The general arrangement of the proposed land catapult is as follows:

*Track*

There are two possible arrangements of the track worth considering: one employing a long fixed track and the other using a shorter track capable of rotation. If the winds at the site of the station are reasonably constant in direction, the former is preferable because of its lower cost and longer possible run. If the winds vary widely in direction, the latter is better, since it permits full advantage to be taken of the assistance of the wind in launching and the car is largely relieved of lateral forces.

The fixed straight track is laid in the direction of the prevailing wind and may have a slope downward in the direction of launching. The track is of standard railroad construction and can be built over quite rough terrain using, where necessary, standard railroad practice in the matter of fills, trestles, etc. Use of the track permits take-off from a site where the cost of construction of an aerodrome would be prohibitive. In the case of marine aircraft, the track and car permits the use of smaller protected waters since an aircraft can alight in a much smaller harbour than that from which it can take-off. In this case, if the prevailing wind direction is suitable, the track can be built along the sandy beach or rocky shore of the harbour or bay or of a stream running into it.

For the rotating track, latticed girder construction is used and rotation provided for by supporting the girder at about the quarter points, on two cars running on a large diameter circular track (complete or arc only) or alternatively, by pivoting at one point and using one car on a track of twice the diameter. Beyond the supporting cars, the girder is a cantilever and, at the launching end, can be relatively light because the weight of the aircraft is here becoming air-borne.

The figure given for the average acceleration, using a track 2,000 ft. long, indicates that a much shorter track can be used without encountering excessive accelerations. A rotating track would necessarily be shorter, possibly not over 1,000 ft. long. In either case, length must be provided for deceleration of the car following the launch.

*Car*

The size, shape and arrangement of the car will depend upon the type of drive, type of aircraft, the track and other conditions.

The external form of the car should be carefully designed, possibly after wind tunnel tests, in order that the resistance and interference with the air flow about the aircraft may be reduced to a minimum. If the car produces much disturbance of the flow of air, a difficult change of flight conditions may be encountered during the launch when the aircraft passes beyond the influence of the disturbance.

For the propulsion of the car, there are several alternatives, depending on the length of the track and local conditions. A cable drive appears promising, particularly for a short track although mine practice proves long high speed cable drives practicable. A cable drive for the car of the model testing basin at Ottawa has proved satisfactory. With cable drive, the car can be light, but the weight of the cables will increase the required accelerating force.

For long tracks, self-propelled cars driven by gasoline, Diesel or even steam engines may be used. The tractive effort required will be equal to the sum of the drag of the aircraft, car resistance and accelerating force. The resistance of the car, including rolling and journal friction and air drag will increase with speed up to about 25 lb. per ton at top speed. This is relatively small and, together with the drag of the aircraft, may be assumed to be taken care of by the thrust of the airscrews of the aircraft.

Assuming constant acceleration, the accelerating force for the suggested catapult of the foregoing cable will be one-sixth the total weight of the aircraft and car. A reasonable value for the coefficient of traction between wheels and rails is 0.25 and, as this exceeds the accelerating force coefficient, it is clear that any weight of car will provide sufficient traction if the lift of the wings does not exceed one-third the weight of the aircraft. To reduce the force and power for acceleration, the weight of the car should be kept low. If it is assumed equal to one-half the weight $W$ of the aircraft, the average total accelerating force will be $W/4$, traction will be $3/8\ W$ and the maximum power (constant acceleration) required will be about 0.07 $W$ hp. For a 25-ton aircraft, the accelerating force will be 12,500 lb. and the maximum power 3,500 hp.

However, the accelerations would not, in practice, be constant, but vary, being high at the beginning of the run and dropping to zero at the instant of launching and the maximum power required would then be much less than that given.

The principal handicap of wheel traction drive for the car is the weight of the motive power and the vicious circle that results from weight requiring power to accelerate and power, in turn, requiring weight.

An attractive form of drive is by means of aircraft engines and airscrews. The aircraft engine is the lightest type of prime mover, hence the car can be very light and traction difficulties are avoided. Airscrews designed for the particular low speed conditions are used and the engines are operated at full take-off power for the short time necessary for the launching.

For the example considered, assuming the car weight is reduced to $W/4$ with airscrew drive, the accelerating force (constant acceleration) will be about $W/5$ and the maximum power about .04 $W$ or, for a 25-ton aircraft, 10,000 lb. and 2,000 hp., respectively. By using four 500-600 hp. engines, mounted on cantilever outriggers on each side of the car, the airscrews will be well below the aircraft wings and an effective drive provided.

An operator, riding on the car, controls the speed, to accelerate in the desired way and, after the launch, brings the car to rest.

*Cradle*

The aircraft cradle is pivoted in the car to permit the aircraft to align itself (weather-vane) with the relative wind. The aircraft is cradled at a fixed incidence, slightly below that of maximum lift and held in place by a locking device. On reaching launching speed, acceleration is reduced to zero and the speed of the car held constant until the pilot signals and releases the lock. The car then begins to decelerate and the aircraft flies off.

With ample accelerating thrust available from the car, there is no need to reduce the aircraft drag during acceleration, by cradling the aircraft on a tilting cradle at the incidence of minimum drag and, at the instant of take-off, increase the incidence by use of the aircraft controls. A slight freedom in tilt may be desirable to enable the pilot to feel if the aircraft controls are set appropriately for the speed at launching.

The aircraft may be lifted from the ground or water and placed on the cradle by means of a rotating crane as in the D.L.H. depot ships.

## APPENDIX XI

### Mayo Composite Aircraft

The reported construction and performance details of the composite aircraft, now under construction, are as follows:

Upper Component—'Mercury'

Four-engined, high wing, float seaplane—span 73 ft. 0 in.; length 51 ft. 0 in.; height 20 ft. 3 in.; wing area 611 sq. ft.; tare weight 9,760 lb.; gross weight 20,000 lb.

Engines—Four Napier Rapier, Series V, 16-cylinder, air-cooled H engines; dry weight 720 lb.

Power—rated 315 hp. at 10,000 ft.
maximum, 340 hp. at 13,000 ft.
maximum r.p.m. 4,000.

Propellers—Fixed pitch, wooden.

Performance—Specified range 3,500 miles with 1,000 lb. of mail. Predicted range 3,380 miles in still air or 2,150 miles against 60-mile headwind, with possibly 4,000 lb. mail.

Lower Component—'Maia'

Four-engined, high wing, flying boat, similar to Short Empire boats—span 114 ft. 0 in.; length 84 ft. 11 in.; height 32 ft. 7 in.; wing area 1,750 sq. ft.

Engines—Four Bristol Pegasus.

Composite Aircraft

Combined horsepower nearly 5,000.

Power loading about 11 lb. per hp.

Combined weight about 42,000 lb.

## APPENDIX XII

### The Ice Hazard

Until the advent of modern commercial air transport, operating on fixed routes, on regular schedules, in all seasons and in all kinds of weather, the ice hazard was not serious. In recent years, however, there have been an increasing number of interruptions to commercial services and forced landings, some disastrous, due to this cause.

The meteorological and physical conditions and processes leading to the formation of ice on aircraft are complex and are not yet properly understood. Hence the hazard is difficult to forecast accurately even with the best of meteorological organizations.

*Character of the Ice Deposit*

The nature of the ice formation varies with the conditions. Three principal types of deposit are generally recognized:

1. Clear ice or "glaze," normally smooth but which may be rough when mixed with snow or sleet or ridged when freezing is slow. The ice builds up on the leading edge in a blunt nosed shape, i.e., "mushrooms," tapering sharply to the rear. Occasionally the wings are covered both top and bottom, and icicles form at the trailing edge. The ice adheres tenaciously. This type of ice has the most serious effects.
2. Hard, white, opaque granular deposit or "rime" which builds forward from the leading edge in a sharp-nosed shape. Rime is encountered more frequently but generally adheres less tenaciously than clear ice, except at very low temperatures, and is less serious.
3. Frost, a light feathery crystalline deposit with little adhesion, which is not dangerous.

*Conditions*

Ice deposition in serious amounts occurs practically only when the aircraft is in some form of visible moisture, cloud, fog, rain or mist, at temperatures below and close to 32 deg. F. and high relative humidity, 90 per cent or over.

Supercooled water droplets in the air remain liquid at temperatures below freezing, and have been observed at surprisingly low temperatures, as for instance −4 deg. F. in America, −29.2 deg. F. in fog in Greenland and −37.2 deg. F. in Antarctica. The supercooled state is unstable, and on collision with the aircraft the droplets freeze. On impact, part of the droplet freezes, forming a slushy mixture at 32 deg. F. which changes to ice as the latent heat is removed through evaporation or conduction to the structure. The rapidity of freezing depends on the degree of supercooling. Droplets at, or a few degrees below 32 deg. F. freeze slowly to form clear ice; if highly supercooled, at several degrees below freezing, the droplets freeze rapidly to form rime. Apparently large droplets, as in rain, generally form clear ice and the minute droplets of clouds form rime. If droplets of different sizes are present, the deposit may be either clear ice or rime and if the former, the coating will be rough. Most rapid icing usually occurs where there is temperature inversion and rain is falling from comparatively warm clouds above on a layer of air or cloud at a temperature below freezing in which the aircraft is flying.

A thin coating of ice may be formed in clear air above cloud, from the moisture collected in passing through the cloud.

Occasionally icing occurs at temperatures above freezing when the aircraft is flying in a layer of dry air on which rain is falling from above. Evaporation of the liquid film on the aircraft causes, as long as the surface is wet, a temperature drop of several degrees depending on the relative humidity, sufficient to result in freezing especially since the rain drops falling through the dry layer are themselves cooled by evaporation, below air temperature, and may be supercooled. Cooling also results from adiabatic expansion of the air flowing over the wing surface. The latter cooling is greatest at the points of highest velocity.

The formation of frost on aircraft is a result of sublimation and therefore dependent on a state of supersaturation with respect to ice. Frosting may occur when, after being cooled to a low temperature in a cold strata, an aircraft descends rapidly into a highly saturated layer at a higher but still subfreezing temperature. Frosting may also occur in flight in nearly saturated air at a temperature below freezing due to adiabatic cooling.

Sleet alone does not collect on aircraft, but mixed with rain may form a rough and dangerous coating. Similarly, dry snow does not adhere, but a mixture of snow and rain or cloud droplets will likely result in a heavy deposit of frozen slush. Clouds composed of ice spicules do not form any appreciable deposit.

The structural material of the aircraft is of importance only insofar as it affects the start of the ice formation. The rate of growth, after the initial coating, varies but little. There is some indication that highly polished surfaces reduce the adhesion of ice, and that roughness such as seams and rivets favour icing. Thick wing monoplanes appear to be less susceptible to icing than thin wing biplanes.

High speeds favour icing through increasing the quantity of moisture encountered in a given time, the rate of heat dissipation, and the adiabatic cooling.

Records of autographic meteorological instruments carried by aircraft indicate that in the United States clear ice may begin to form at temperatures from 33.8 to 1.4 deg. F. and rime from 33.8 deg. F. to −4 deg. F. but that most frequently clear ice commences at 32 deg. F. and rime at 28.4 deg. F. Rime occurs two or three times as frequently as ice. Both types are encountered most frequently at elevations between 1,500 and 5,000 ft. and somewhat less often at 8,000 to 10,000 ft. for clear ice and 13,000 to 15,000 for rime, but icing may be met with at any elevation within the range covered, i.e., up to 18,000 ft. The region from 6,500 to 8,000 ft. is one of low frequency for both types.

Clear ice and rime form most frequently in strato-cumulus clouds, with high frequencies also, for clear ice in alto-stratus and for rime in stratus clouds. No deposits were reported in cumulus clouds doubtless because flights were made before daylight. Cumulus and strato-cumulus are known to be favourable to icing.

*Effects*

The effects of the accumulation of ice on aircraft are numerous and serious.

The most serious effect of icing is the deformation of the aerodynamic forms, particularly of the wing and tail surfaces and the resulting adverse effects on performance. Lift is decreased, and drag increased, to such an extent in many cases that flight cannot be maintained even at full throttle. The cleaner the aerodynamic design, the more quickly are the effects apparent.

The malformation resulting from ice causes vibration of wires, wing tips and tail which, at high speed, may start very suddenly and may cause failure of the part.

The increase in weight due to icing is generally of secondary importance. The additional load is partly offset by the weight of the fuel consumed during the accumulation of the ice. The effect of the weight of the ice is chiefly noticeable in banking.

In spite of centrifugal force, the airscrew is also subject to icing. In addition to the effects on efficiency, deposits on the airscrew constitute a serious hazard if thrown off irregularly. Balance is destroyed and vibrations, in extreme cases of a disastrous character, are caused. To minimize vibration, throttling is often necessary, leading to more rapid icing of the airscrew. The disturbances are amplified by the gears in a geared engine.

Ice may interfere with the movement of control surfaces and of external controls. The latter is not serious in modern aircraft with interior controls.

The power plant may be affected through the freezing of radiator shutters, clogging of air intake screen and closing of tank and crank case vents if they project into the air stream.

Instruments are also affected through the icing of such elements as Venturis, air speed heads, windmills and radio antenna, both trailing and fixed.

Windows may be coated, and, if sliding, may freeze tight and prevent their operation in landing.

# Industrial Zoning

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

**There has already been definite progress towards the state control of industry in Great Britain, particularly as regards unemployment and the location of industries. The author believes that this will continue and that ultimate success will largely depend on the provision of cheap transport and cheap power.**

In putting forward for consideration on this occasion a paper with this title and subject, some word of explanation, and it may be apology, is needed. A purely technical engineering paper would be much more easily transplanted from one country to another, than can be a paper which deals with the adaptation of engineering experience and training to the economic solution of the particular problems of my own country. This paper does not seek, and could not attempt, to discuss conditions or problems in Canada. It deals specifically with those of Great Britain. But although conditions there are in many ways so different that it might seem no analogies could be drawn, fundamentally the evils of industrial depression and unemployment, and their causes are, I am convinced, the same or very similar on both sides of the Atlantic. If it were otherwise it would be merely to waste your time and your patience, to offer a paper that could have no application to your own conditions, and no interest to yourselves. I believe, however, on the contrary, that there is a good deal that you can learn from our mistakes—and at worst you may be able to offer us useful constructive criticism when you know the facts.

With this explanation and apology, I will proceed to discuss the subject of my paper—Industrial Zoning—wholly and solely from the point of view of my own country, and by way of examination of those conditions, of which alone I have first hand knowledge. In the first place I would explain what I mean to include in "Industrial Zoning." It will, I hope, emerge more clearly in the course of the paper, but it will simplify matters for me to explain at once that I take the title, for want of something better, to refer to the whole question of the economic and technical direction of a nation's industrial activities for the greatest efficiency and greatest convenience.

We have had something like two hundred years of industrialization in Great Britain, certainly one hundred and fifty years of quite intense industrialization. By 1800 there was already the nucleus of a Black Country. It may therefore seem curious and pathetic that at this stage of our history we should be discussing the question of industrial planning—but so it is. The fact is, that it is only in recent years that governments and rulers have found themselves faced with the necessity of making effective decisions and taking active steps on such matters as to how industries shall be encouraged and protected, and where and in what circumstances they shall operate. This is a complete reversal of the whole attitude of our country for the past six generations. It means the definite interference by government in private and business activities to an ever-increasing degree. But in spite of that it is quite generally recognized that the necessity exists; and practically the only debate is how this new obligation of government is to be exercised. And a very grave problem and responsibility it is proving.

May I give you a few facts and figures of our own country, so as to fill in the background to these problems as they present themselves to us in Great Britain.

Figure 1 shows an industrial map of Great Britain. If we exclude all north of a line joining Glasgow with Aberdeen, and all west of a line joining Glasgow with Swansea in South Wales, we shall have an area of approximately 61,000 square miles, which contains almost the whole industrial life of Great Britain, and over 95 per cent of the population. In this area there are 46,000 miles of railway; and 25,000 miles of first-class roads, with a network of good secondary roads. There are more than a thousand miles of modernized and well-used internal navigation. There are at least sixty recognized ports, and there is no spot more than 60 miles from the sea coast. Geographically, therefore, it would seem that there could scarcely be a more ideal position for economical development.

With regard to resources, we have at least 100,000 million tons of proved reserves of coal, the equivalent of, say, four hundred years working at our highest output. We have still extensive deposits of iron ore, including perhaps the cheapest workings in the world—Corby, in Northampton—where the ore is probably mined and delivered at a cost of 1s. 6d. (say 36 cents) per long ton at the adjacent steelworks. Admittedly there are many raw materials and natural resources that we have not. But I would only say this, that the natural riches that first started our industrial developments are by no means exhausted.

Taking another point of view we have probably not much less than £400 per head of population invested in industry and manufacture. We manufacture £2,000,000,000 worth of goods a year—excluding the annual value of food, drink, timber, mining industries, as well as building and contracting, and public utility companies, which between them total another £1,500,000,000 per annum. Our imports and exports approach £1,500,000,000, and our overseas invisible exports, in such services as shipping, banking, insurance, etc., total another £350,000,000. We have the highest value of exports of any country in the world. We are easily the premier ship-building nation. Our steel and iron output in 1936 was the greatest in our history.

By many standards then we are not unsuccessful. Lest, however, you should think that I speak in any spirit of boasting, I now refer you to Fig. 2, which eloquently illustrates the domestic problem which most deeply concerns us now in Great Britain—namely, the existence of large derelict or semi-derelict regions known as the Depressed Areas, or, more euphemistically, the Special Areas. They are shown black, and comprise those parts of the country where, broadly speaking, the unemployed population averages—or until recently averaged—more than 35 per cent of the available labour. In many parts the average unemployment is higher, in a few cases up to 80, 90 and almost 100 per cent.

If one were to include as well, all those areas where the percentage is as high as 25 per cent, very much more of the map would be coloured black. Since 1919 we have never had less than about one and a half to two millions of male unemployed; and when two years ago special action was taken in respect of the distressed areas, the unemployment figure for the whole of Great Britain was 16.3 per cent. In 1931-2, the figure far exceeded three million, and even now when we are in the midst of a kind of a boom, there are still probably over two and a quarter millions. I say "probably," because it is exceedingly

Fig. 1—Great Britain, Areas of Major Industrialization.

Fig. 2—The Special Areas as Defined by the Special Areas (Development and Improvement) Act of 1934.

difficult to interpret all the unemployment figures, and it would merely confuse the issue to descend to details that do not affect the broad principles.

Unemployment has thus apparently become one of the chronic phases of our industrial conditions. For every six men on the pay roll there is one invisible employee permanently to be carried who does nothing for his cost. Our unemployment relief system has been fiercely criticized. But after all, in this as in so many other of our problems, there is no alternative. Civilization and humanity will no longer permit such matters to be ruled solely by the harsh economic laws of nature. Our annual expenditure on unemployment, taking into consideration all the different channels of relief, is not less than £200,000,000, the equivalent of over 20 per cent of our national budget. This, as a serious handicap on industry, needs no emphasis. The deplorable state of affairs is even a greater potential handicap, in its effect on the character and morale of a large part of our citizenship. May I quote from a report that was recently made public, giving the results of a conscientious and sympathetic enquiry by a hard-headed, cold-blooded engineer into the possibilities of reviving industry in one of the hardest hit of all our depressed or special areas—

> "Turning now to more detailed consideration of South West Durham, the most immediate apparent fact in present conditions is that the grouping of population and the location of villages having been fixed solely by the position of coal pits, the result is a haphazard, illogical and now utterly uneconomic state of affairs. Many of the villages have been left as it were by the receding tide, in deserted, stagnant backwaters. No traffic stream will ever come near them again. There is no hope or chance of any industry ever being established in their midst. There cannot even be an efficient supply of ordinary services, schools, drainage, etc. The outlook of people in such circumstances must be hopeless and demoralized in the extreme. They have never had any amenities and but few services; and now they have no prospects.
>
> Since owing to their situation, neither industry nor even civilized conditions can ever come to these isolated spots, it is our suggestion that the worst and most isolated of such villages should be abandoned and demolished and the individuals housed elsewhere, where they can receive the facilities, services and amenities that they should, and at least have some hope of obtaining employment.
>
> Owing to the limited prospects of industrialization within South West Durham, most of such re-housing should be outside it. But a proportion should be in specially selected places within the area. This re-settlement should be made part of a definite and detailed survey and study, so as to plan the district generally on new lines—that is to say concentrate the population from derelict and backwater villages into strategic centres, with good communications and all social services. By this means labour could at least be organized so as to be available, if and when the demand for it arose. In due course, too, if industries should turn to this area, there would be suitable localities for them to go to. Improved roads will in themselves bring increased traffic, which will in turn induce development and business. Moreover, the provision of modern social services would incidentally be much more economical and satisfactory; and the moral and mental deterioration of a considerable portion of the community would be prevented."

That may appear pessimistic, but it has, I think, to be accepted as fundamentally true. In South Wales the position is in some parts even more acute. Although the prospects of revival of industry are more promising, the numbers involved are much larger. In a monumental Survey,* just completed (1937), Professor Marquand sums up as follows—

> "Our Survey of the industrial situation of the Region has revealed that there has been a measure of recovery from the depths of the depression of 1930-1933; but that there still remains a mass of chronic unemployment which is peculiar to this and other depressed regions which have not developed large new industries to compensate for the contraction of basic activities such as coal-mining and steel-making. The population of the Region is rapidly adjusting itself to the changed circumstances by migration from the Region. Such growth of new enterprises as has taken place has been too small to make any appreciable reduction of the surplus of labour attached to the older industries."

Merthyr Tydfil with a population of over 80,000, long since dwindling and now below 65,000, epitomises in concentrated form the experience of South Wales. For one hundred and fifty years the area ranked as one of the most important iron and steel centres in the world. At one time it easily outdistanced all competition. The great Dowlais works where Bessemer carried out his experiments were in operation before 1750. The Cyfarthfa works were in 1803 the largest industrial iron works in the world; and there were at least two other great works at Merthyr. All are now derelict, and there is scarcely a prosperous business in the town. The local rates are now the highest in the whole country—27s. 6d. in the £, as compared with an average throughout the country of probably 9s.; and of these rates 55 per cent is required for Public Assistance.

I will not pursue the matter. I have said enough to show how serious is the problem and to what a considerable degree our industrial plan—so far as any hitherto existed—has broken down. Let me now briefly refer to some of the causes of the breakdown as they appear to me.

Unemployment and depression have been world wide. Every industry and business almost has been affected. In our own country there has in the last three years been a general improvement, led by an unusual and unexpected expansion of speculative house building, and maintained or at least accentuated by the rearmament programme. But this minor boom only serves to illustrate even more clearly how permanently unemployment seems to have become established and concentrated in certain industries and certain localities.

What are the special causes? They may, I think, be summarized as follows:

- Antiquated plant and obsolete processes unable to compete with more modern and more efficient methods.
- Exhaustion of old sources of supply, and the discovery of alternative raw materials; the substitution of new products for old—for instance, of oil for coal.
- Removal of industry to more suitable locations, as the big Welsh steel works from the narrow inland valleys to the sea coast.
- Mechanization.
- Rationalization.
- Political reasons, such as the policies of foreign countries and of our own Government; trade barriers, protection, subsidies, national self-sufficiency.
- Financial reasons, such as deflation and the premature return to the Gold Standard.
- Uneconomic and inefficient administration of many of the great industrial companies.
- Over expansion, required during the war for national reasons, and encouraged by the notorious Excess Profits Duty, led to the creation of fixed assets that subsequently turned out to be heavy liabilities.

And I would venture to add:

- Nepotism in administration. The attempt to retain family control of the big industrial businesses that were started in the latter half of the last century, has almost invariably been disastrous.

Both to employers and employed in some, perhaps most, of the basic heavy industries on which our pre-war progress was based, prosperity and money came too easily. Professor Marquand, in his survey, points out that "although South Wales has a long record of iron and tinplate production, it has never developed an important engineering industry. This failure of South Wales to develop an important engineering industry, like its failure to develop other secondary industries, was caused by the concentration

*The Second Industrial Survey of South Wales, 1937 (Marquand).

on coal and tinplate in the times of prosperity." The position was much the same on the West Durham coal field.

Although there is at the moment such a strain on the resources of our steel and iron industries, that we are experiencing something in the nature of a boom, and all the worries of rationing of steel and other supplies; and although in other directions—such as ship-building—there has been a remarkable improvement in the last two years, yet there are still industries severely hit, such as mining, textiles, railways and shipping. Except in the south-east and round Birmingham, real prosperity is still some considerable way off.

But attention is naturally focussed on the special or depressed areas, and on the many steps that government has taken to alleviate conditions there, and the many plans to that end that have been recommended to government. It is of importance, therefore, to consider exactly what has been the nature and extent of this new form of direct intervention by the State into the promotion of individual industrial activity. The policy of the Government was stated as follows by Mr. Neville Chamberlain at the end of 1934—

> "Although in the present case we need not describe the disease as desperate it certainly is sufficiently exceptional to warrant exceptional treatment. What we want here, as it seems to us, is something more rapid, more direct, less orthodox if you like, than the ordinary plan, and if we are to do what seems to me even more important than the improvement of the physical condition, if we are to effect the spiritual regeneration of these areas, and if we are to inspire their people with a new interest in life and a new hope for the future, we have to convince them that these reports are not going to gather dust in some remote pigeon hole but that they will be the subject of continuous executive action . . .
>
> "We have resolved to cut through all the ordinary methods and adopt a plan which we conceive is more suitable to these special conditions than the methods which, in the ordinary course, would be applied to such a problem . . .
>
> "We are going to give the Commissioners (who were specifically appointed by the Special Areas (Development and Improvement) Act of 1934, a very wide discretion. They must not be afraid of trying experiments even if those experiments fail."

Up to date a sum of about £20,000,000 has been expended under this new legislation, or is pledged for expenditure in the special areas. Considerable assistance has been given to all sorts of social improvement plans, the provision of necessary services, land settlement, remedial work such as the renovation and extension of derelict harbours, the provision of capital at low rates for new speculative and struggling factories with very moderate, or sometimes no, security. There are other and numerous unusual inducements offered to manufacturers to settle in the special areas, provision of free sites, assistance in the building of factories, partial remission of rates and rentals, etc. In addition to such concrete action, there is a vast deal of quiet and unobtrusive persuasion, particularly in regard to foreign immigrants who require permits for permanent residence in Great Britain.

All these efforts, very briefly summarized above, are openly and definitely directed solely to the encouragement of industries to establish themselves in certain parts of the country, for the sole reason that there is in those parts an excess of unemployment. In the circumstances it has not been attempted to take a broader view. In this the government has had the assistance of numerous local Industrial Development Councils and Development Boards—which have had a great value as a focus of local activity and enthusiasm, and whose great advantage is that they have never attempted to take other than very local or wholly one-sided and single-minded views of the problem—that of their own locality.

Without implying any criticism of the special area policy, it must be admitted—and is recognized by government—that to act on these lines to any great extent, might involve an upsetting of the industrial balance; and that government has as yet no means of assessing the claims and rights of applicants on the one hand, and of established and threatened industries on the other. Almost every works so established by government assistance in a special area are in competition with some other works that have not had government assistance. Government has been the first to realize the serious implications and responsibilities that would—if pressed too far—necessarily follow from such a policy, forced on them as it has been by circumstances, but contrary to their old conceptions and traditions.

In this connection it is, I think, worth while to consider in rather greater detail the action that government has taken in regard to the setting up of Trading Estates, because here we come more immediately to the problem of industrial planning and zoning. This is in fact the most interesting and important action that has so far been taken, and involves an ultimate commitment of probably £10 to £15 million pounds. There are three government Trading Estates—one in Scotland in Renfrewshire, one at Gateshead south of the Tyne to serve the North East Coast area, and one in South Wales. The first is as yet only in embryo stage; the other two have already progressed some distance. The underlying policy was that they should be designed to encourage the growth of new types of industry in areas hitherto dedicated almost wholly to heavy industries, and that they should thereby spread the risks, so to speak, and tap new uses for the surplus labour.

There have been a number of so called Trading Estates established in Great Britain in the past twenty to thirty years, promoted by private interests and carried on on purely business lines. There is the big Trafford Park Estate on the Manchester Ship Canal, the Slough Trading Estate, the two industrial garden cities of Welwyn and Letchworth, and the Ford Estate and several others near by on the lower Thames. In every case they provide sites, build factories, and give services. The Trafford Park Estate is largely devoted to heavy industry; the Slough Estate, 20 miles west of London, was more or less started from a famous motor dump after the war. According to the latest published figures, about 300 acres have already been developed, at an average rate of about 15 acres a year, holding altogether some 200 factories, employing directly over 20,000 employees. The Slough Estate is an exceedingly well-managed, and now a very prosperous, business.

The industrial garden cities of Letchworth and Welwyn are on rather different lines. They aimed at providing ruralized industrial areas, the sort of development that had taken place at Bournville round the Cadbury's cocoa and chocolate works, or later at Port Sunlight at the Lever Company's soap works. In them industrialization has been on a comparatively smaller scale. Letchworth, started in 1903, housed by 1936 a population of 16,000 and about 60 industries. Welwyn, established in 1920, had in 1936 a population of about 10,000 and 40 factories.

But it was not really any of these developments that inspired the government's new Trading Estate policy, but rather the intense industrial development during the last ten years in London and the Greater London area.

The Greater London area comprises now about 2,000 square miles, and the diameter of the circle is something like 50 miles. The population has increased a million in a decade. In 1905 there were computed to be 14,500 factories in the area. In 1930 there were 27,000, of a greatly increased average size. These factories are mainly of the semi-luxury and consumer-goods type. The reason why they have been established in such numbers in and near London, is solely the proximity to the immense market of 10 million people. Cost of land, building restrictions, difficulties of transport and travel, severe restrictions in regard to noxious fumes and trade effluents, none of these discouraging factors could outweigh the immense advantage of having the consumer within hourly delivery distance of the manufacturer; and so far labour has always been available and amenable. It is this amazing London development that has given rise to the many alarmist reports of the drift of industry from the north of England to the south.

The location of the first government Trading Estate was at Gateshead, and it was decided after the most careful consideration as to the possibility of repeating the London experience there on a smaller scale.

A ten mile circle can be drawn with its centre approximately at Newcastle, to include a population of over one million people, a population that after years of depression is beginning to benefit by the improvement in the steel trades, armaments, munitions, ship-building, etc. It was argued that there was scope for the establishment of a light-industry trading estate on the outskirts of this big potential market. Although 700 acres in extent, the Gateshead Trading Estate is right on the edge of a most thickly-populated area. It is only ten minutes by motor to the centre of Newcastle. Work was only started in the autumn of 1936, and already over 30 factories are being built. It is true that some were attracted by government's special terms, but broadly speaking the original policy clearly is being justified. The capital has been provided by government, but ultimately a reasonable return has to be obtained for it; and the rents have been fixed accordingly, and accepted without difficulty or demur. It is clear, therefore, that in this respect the government Trading Estate has filled a want. I would like, before passing on, to give a sketch (Fig. 3) showing the planning of this Gateshead Estate, because by the close co-operation of engineer and architect it has in fact been sought to lay it out on lines that will avoid the worst failings of some industrial developments.

The South Wales Trading Estate was necessarily planned on rather different lines. The industrialization of Wales having been based on coal and iron, has taken place in the valleys that run inland from Newport and Cardiff, like the fingers of a hand. The transfer of labour from areas where industry has failed, to those parts where labour is wanted, is the obvious and to some extent an inevitable result and solution of such industrial decay as has taken place in the depressed areas. But South Wales has already lost heavily in population since the war. Nearly a quarter of a million have migrated, being nearly 10 per cent of its population; and there has been an actual net fall of population of at least 100,000. If this drain were not checked Wales would be destined to become depopulated. On the other hand transfer within the area of South Wales itself was considered uneconomic. The houses and the services already existed, and the wholesale abandonment of adequate habitations and their rebuilding a few miles away seemed unjustifiable, and would certainly have been very unpopular. Moreover there is not the concentration of population in South Wales that there is in the Newcastle area. The same objectives could not, therefore, be sought, and it was for consideration whether a Trading Estate was justified. A Trading Estate was ultimately designed on smaller grounds and was located in one of the populous valleys within a few miles of Cardiff, and also within reach of several of the most stricken valleys, there being an unemployed population of 31,000 in a ten-mile circle from it. The arguments then were not the same as on the North East Coast; and they had regard perhaps a little less to the industrial than to the local and psychological aspects. But these too are considerations that must be borne in mind in planning. A senior medical officer in Wales recently found an explanation for some of the abnormal developments in medical history in that country in "the national characteristics of the Welsh, for example, the intense conservatism of their social habits, the closeness and tenacity of their family relationships, and their fatalistic outlook." In those characteristics are to be found, too, many of the causes both of their success and of the exceptional difficulty of their present industrial position. Psychological conditions, in fact, play no small

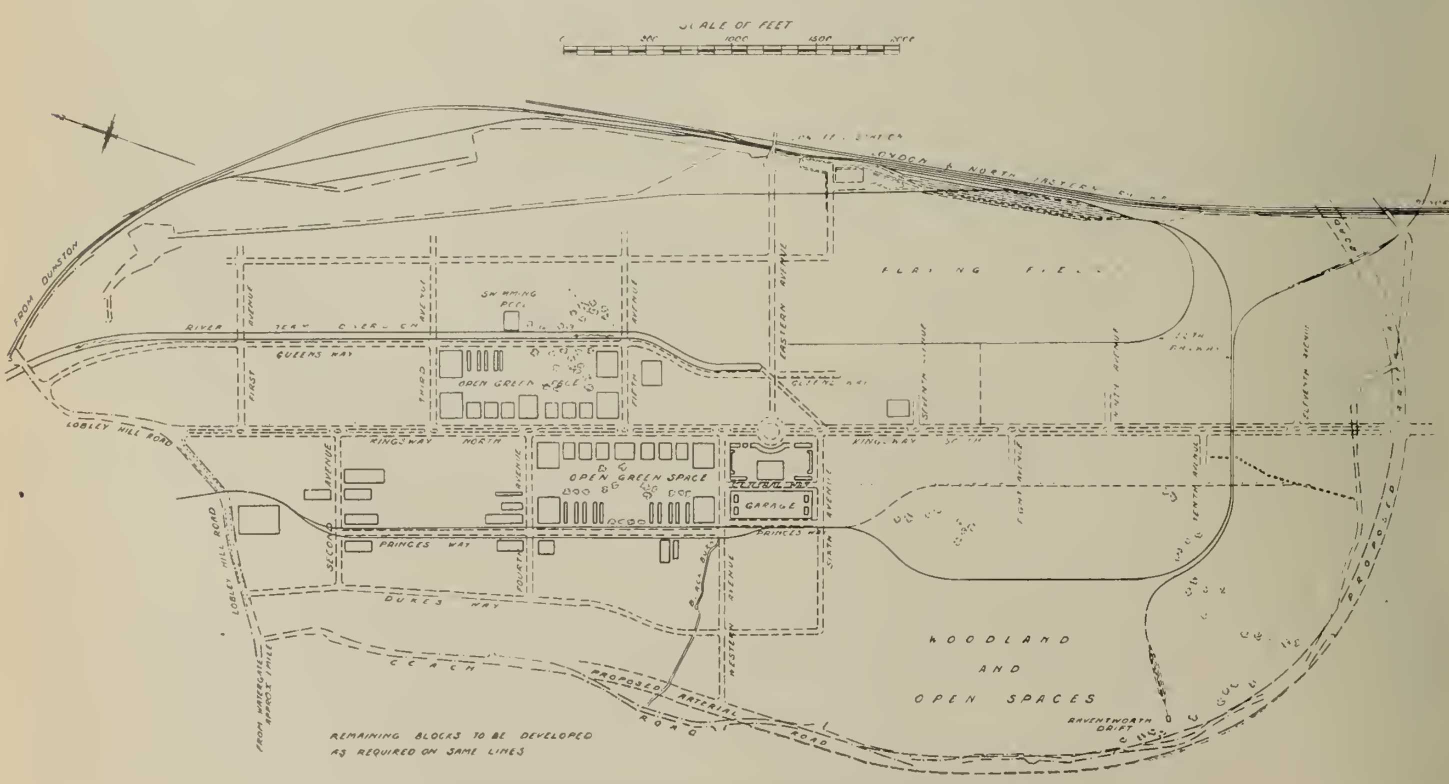


Fig. 3—Government Trading Estate on Tyneside.

part in many of the special areas. In West Durham and West Cumberland, for instance, one of the major difficulties is the absence of big leadership—in which respect the North East Coast has fortunately never failed.

These activities of government have not been made without incurring considerable criticism and doubt. Some critics have been inspired quite naturally by the threat to their own existing interests; others on broader grounds have deprecated the intrusion of government into the industrial arena; others though sympathetic have been unconvinced of the likely success of the measures adopted. But these critics have none of them fully realized how many steps government had already, and long since, taken in this very direction of directly influencing and controlling industry, and in fact actually participating in industrial activity. A few instances will suffice. There is now operating in Great Britain a very close steel federation, which was forced into existence in the teeth of opposition and warring interests, largely by the power of the Bank of England, obviously and admittedly interpreting the views of the government. It was quite openly promised that a measure of protection would be granted by government, as soon as the steel makers had "put their house in order," along lines that met with government's approval—and not otherwise. Government's action in this respect has had the profoundest effect on industrial activity in Great Britain.

Again in connection generally with protective tariffs, which have apparently become part of the permanent policy of all our political parties, there is an Imports Duties Advisory Committee whose primary task it is to examine the arguments put forward by different trades asking for tariff protection; and on their advice government may decide to protect a particular manufacture or not. It has been a natural development for this Committee to be employed by government to examine generally into economic and industrial questions, such as the feasibility or practicability of new manufacturing proposals that are submitted to government by private interests.

Government is in fact increasingly finding itself faced with such problems. Quite recently there has been considerable debate and agitation on the question of the manufacture of calcium carbide in Great Britain, which is at present all imported. It seems practically certain that its manufacture without tariff protection is not practicable, because of the great difference in the cost of power between Great Britain and Norway. Be that as it may, a proposal was brought forward by private interests, which did not immediately ask for any government assistance, beyond the securing of statutory powers to develop hydro-electric power in the Highlands of Scotland. Great pressure was brought to bear on government from different sides to support the scheme as of national importance, and contrariwise to oppose it, unless it were located in one of the Special Areas. The arguments and the struggle were heated in the extreme. They became almost wholly centred on the "special areas plea" without much consideration of any other points. Government itself succeeded in remaining more or less neutral, and the proposal failed in Parliament. But it has now been announced that government will appoint a committee to discover whether or not carbide could or should be manufactured in Great Britain. If it decides favourably, presumably government will take steps to initiate the new manufacture.

A similar investigation is now being made into the question of the development on a large scale in Great Britain of the German Fischer-Tropsch process for the distillation of oil from coal. Another great controversy raged a year ago, again involving government and its advisers, in regard to the proposed establishment of a steel works at Jarrow on Tyne, where grave unemployment had existed, and still exists, by the collapse more than twelve years ago of the great shipbuilding firm of Palmers.

These are only a few instances—but they are sufficient to show that, whether it is theoretically desirable or not, government has already practically become the absolute arbiter to decide, in the final recourse, as to the establishment and location of any new industry. It seems certain that such responsibility will increase; and seeing that obviously there is as yet no sort of definite national policy, nor even the information on which to base such a policy, the appointment of a Royal Commission which was recently announced, to study the question of the location of industry and kindred matters, is clearly not premature.

When that Royal Commission starts its review—or whenever and in whatever way government, or legislators, economists or industrialists seek to reach definite conclusions as to the policy that should govern the establishment and location of industry in Great Britain—then it is essential that the long view rather than the local view shall be taken. It is, for instance, not necessarily to be assumed, because "depressed areas" exist, with large aggregations of unemployed people, that it is ultimately either sound economics or in the widest national interest to re-establish new industries there. It is the natural course; it may seem the most humane; but it may not really be the wisest. I am not saying that I myself would subscribe to such a view but one is not justified in taking it for granted one way or the other, and then basing one's solution of the problem on what may be a faulty premise. Without ceding to anyone in active sympathy with the special areas, it has to be remembered that in population they represent but 7 per cent of the whole population of Great Britain and that while there are something over 350,000 unemployed in the Special Areas, there are five times as many unemployed spread over the rest of the country. There are other areas and other industries that have been for years in only slightly worse state than the special areas.

On the other hand it is equally not to be assumed, for instance, that the boundless extension of London, industrially or domestically, is necessarily advantageous. There are many who think it should be prevented. Others confidently and happily estimate that the growth of the future will far exceed that which has so far taken place. One distinguished economist recently calculated that half the population of England and Wales would be living in London by the end of this century. At present its share is only a little over a quarter. Sir Raymond Unwin, Past President of the Royal Institute of British Architects, has made a careful study of 1,145 entirely new factories that were established in London itself in the ten or twelve years following the war, employing directly 131,569, and thus affecting a population of at least 500,000, a fresh industrial city in itself—fifty times the size of Welwyn. Had it been split up into say five industrial units, he claimed that in all respects the position would have been more satisfactory and sounder. This will provide a knotty problem for the Royal Commission on the location of industry.

But in fact the drawing up of any detailed instructions in such a matter as the location of industry does seem an almost impossible task. If and when the power of decision as to the establishment or prevention of individual industries lies with government, except in special circumstances, it would end all private enterprise. On the other hand, government should be able to ascertain the basic causes that are handicapping existing industry, or preventing new industries from being established; and the main factors that have operated favourably or unfavourably in existing and past industrial developments.

If I may quote from a work to which I have already referred: "Alfred Weber's well-known work on the location of industry* was intended to be the preliminary to a realistic description of the facts of existing industrial location in Germany. He never completed his realistic study; but since he wrote, many descriptive accounts have been written which throw light upon the theory. The time indeed seems ripe for a further careful statement of how the theory of location stands to-day. There is reason to doubt whether the theory can ever become sufficiently positive to be applied without hesitation to any concrete situation. But we ought, nevertheless, to avail ourselves of all the lessons which can be easily derived from past experience."

The root of the whole matter will, I believe, be found to be in cheap transport and cheap power. In 1921 was passed the Railways Act which—more or less compulsorily—amalgamated into four main systems the 123 railways, large and small, which still survived from the many hundreds promoted and built in the years between 1830 and 1910. I would be venturing on a thorny path were I to explore in detail the present railway position. But I venture to say that ultimately government, or at least centralized control, will become complete. The pressure for co-ordination and rationalisation in order to cheapen transport will increase until finally the four railway groups will become one. The complete main line electrification recommended by a commission some years ago at a cost of £250,000,000 would by itself involve government financing and probably government control direct or indirect.

The growing complexity of modern transport and the inter-dependence of all forms of activity, do indeed seem to make it proper that the burden of such an essential service as transport should be undertaken by the State, for not only is the cost of transport the principal item in many manufactures; but is becoming the arbiter of modern life. It is for instance transport alone that makes great cities possible, which in these times provide one of the great social, economic and political problems we have to face. At the same time, nowhere is such hopelessly chaotic and inefficient cross-carriage of goods and passengers to be seen as in our great cities. Mr. Pick, the chief executive of the London Passenger Transport Board, quotes in his presidential address to the British Institute of Transport, the case of two large boroughs of London, Acton and Hammersmith, which are both residential and manufacturing areas, with populations respectively of 70,500 and 135,500. Acton turns out 13,500 workers and takes in 14,500; Hammersmith turns out 32,000 and takes in 29,000. The residents of many of the dormitory suburbs of London spend two to three hours a day travelling to and from their work.

Quite recently the central government has taken over all the trunk roads in the country. This foreshadows a national policy in regard to road transport.

The Road and Rail Traffic Act of 1933 was designed to control to some extent road traffic in order to bring co-ordination between rail and road services. But road transport is still a free agent as regards charges, and for competition for traffic; of the 400,000 or so vehicles on British roads in 1934, 70 to 80 per cent were owned by manufacturers or dealers in commodities. The issue of vehicle licences is now being pretty str'ctly administered; but there is still a great deal of costly and futile competition taking place, to no one's ultimate prosperity.

The ports of Great Britain are not centrally controlled to the extent that the national ports of Canada are. In some ways and for some reasons—but not as yet financial—such a policy may be even more desirable in our country. If a circle of 100 miles be drawn from any of the major ports in England, London, Southampton, Bristol, Liverpool, Hull, Tyne, they will each be found to have a distribution area of about 20,000,000 persons—a total of three times the population of Great Britain. Obviously there must be much overlapping. The benefits of coastwise traffic in permitting the cheapest form of carriage for many things have only been very partially utilized. Tramp shipping has recently been assisted by our government but it is difficult to estimate how this is affecting other classes of transport.

If, as is clear, transport may be the ruling factor in the location of industry; if cost of transport is a preponderating factor in the industrial growth of big cities, which it were desired to limit; if it were decided to simplify the whole position and remove anomalies and handicaps, then there might well be arguments, for instance, for the establishment of flat rates for transport, irrespective of distance, possibly calculated as a percentage on the cost of the material to be transported. At any rate in spite of the fact that we have had a Royal Commission on Transport, we yet lack a national transport policy.

The other direction in which most can be done to create favourable conditions for industry as a whole and particularly for the establishment of new types of industry, is, I believe, the provision of cheap power. We have in Great Britain no low priced hydro-electric power as compared with what Canada is used to. Our cheapest development is probably about £3.10.0 per kilowatt year, say $17. It is certain that no power has been developed in Great Britain at that price since the war, nor can be. Moreover our water power resources are for the most part remote from industry and in areas where industry could not generally be economically established. This means that electro-chemical or electro-metallurgical industries must rely on steam power, the cheapest being about £6 per kilowatt year, say $30. Through the Central Electricity Board, there is already control of the generation and to a considerable extent, of the distribution of power. Very recent announcements indicate the ultimate complete centralized control of all electrical distribution. The establishment of such manufactures as ferro-alloys, and calcium carbide, would require, I think, a guaranteed rate for power of not more than £5 per kilowatt year, or say $25, to be available, whether the factories were immediately adjoining a super-power station or not. Though still high as compared with water power figures, other considerations such as saving in transport, suitability of conditions, raw materials, labour, proximity of markets, the use of process steam, and so on, would, I consider, make that figure economically justifiable as the basis of a new chemical engineering development in Great Britain.

Another direction in which government activity must soon be taken, is in the provision of industrial water and the means of disposal of trade effluent. The control of underground water resources will certainly soon be necessary, since the continuance of uncontrolled competitive boring is likely to prove disastrously costly in the end; while on the other hand the very proper campaign to prevent pollution of streams and rivers, must be accompanied by a policy for handling trade effluent through the common sewerage systems.

Cheap fuel is another vital necessity to industry, that has been recognized by government, but not yet achieved. But the British Government has just acquired by purchase the whole coal royalties in Great Britain, and by recent legislation all underground petroleum and oil has been declared to be the property of the Crown. Pipe lines for transport of refined petroleum would greatly relieve traffic pressure on the roads. There are, I believe, at least 130,000 miles of pipe line in the U.S.A. for crude

*Alfred Weber's Theory of the Location of Industries, translated by C. J. Friedrich (Chicago 1929).

petroleum, and some have more recently been installed there for refined petroleum also. The practicability must be explored of the development on lines that have gone furthest in Russia, of thermal-electric central stations. A Gas "grid" has been established locally in more than one place, but efforts to carry it through on a large scale, making full use of waste gases from blast furnaces and coke ovens, have not yet been very successful.

One other piece of government action I must refer to, the taking over of the greater part of the burden of local rates on manufacturing premises, by what was known as the Derating Act. This remits three quarters of the local rates that would fall to be paid on any building used as a factory. In this, the government in effect undertakes to provide free, such services as sewerage, cleansing, fire protection, watch and ward.

I think enough has been said to show that the government in Great Britain has already moved very far in the direction of the state control of industry and the means of industry. There can be no doubt, I think, that that control will and must increase. It is no longer a question for discussion whether such a policy is wise or not. The question now is as to the lines along which control shall run, and how it can best be used to promote prosperity. Without the wise administration by government of the power of control that it now has, industry—at least in Great Britain—can no longer progress, or indeed survive.

These then are some of the matters that have to be dealt with in Industrial Planning. I have, I fear, merely touched on the fringe, and it is impossible to follow out all the implications and possibilities. There is, however, one final point I would make. In matters of Town and Regional Planning, or in research into the causes for industrial failures, in the replanning of industrial areas, and in the planning of the development of a country's resources—it has been quite rare to find any activity on the part of engineers as a body. The result has been, that rather a one-sided school of thought has grown up regarding Town Planning and Regional Planning. I may quote just one instance—part of the official summary of the results of the International Conference on the subject in Berlin in 1931—

> "The primary aim of planning is to secure the health, comfort and welfare of the people and the first item to be decided should be zoning, that is the disposition of functions: industry, housing, business areas, bulk of buildings, open spaces, etc."

The failures of industrial development in the past have not, however, been due to neglect of amenities—deplorable as that has often been in our country; or to the poor architecture of the factories! It has on the other hand, far too often, resulted from failures in technique, and mechanical inefficiency. Amenities are long since realized as essential even from the most prosaic of manufacturing and business points of view. But amenities cannot dictate the location and operation of industry, on which a country's prosperity ultimately rests.

In Great Britain we have to decide how our main industries are to be strengthened and expanded, how new industries are to be encouraged, how the provision of cheap raw materials is to be safeguarded, how our labour is to be most effectively used, whether we are to change our views as to the concentration of industries in vast manufacturing areas, whether our existing populous areas are to be added to, or decreased—how in fact industry is to be carried on most efficiently and least to the detriment and inconvenience of the people. I imagine that much the same is true in Canada. Those are largely engineering problems, and engineers must take them up.

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# British Engineering Societies and their Aims

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**The mediaeval guilds were the forerunners of engineering societies and were followed by scientific bodies. The activities and objects of the Institution of Civil Engineers and the Institution of Mechanical Engineers are described, with notes on other national and local associations in Great Britain.**

Engineers the wide world over form a vast brotherhood, so that when the writer was asked to deal with engineering institutions in Britain he willingly acceded, feeling that such an account would be of particular interest at the Semicentennial gathering of The Engineering Institute of Canada at Montreal in June 1937.

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Probably the City Livery Companies of London may claim to be the first corporate bodies to give an impetus to the handicrafts which form the basis of engineering as we know it today, and many of these guilds date back to remote times. For instance, the Founders Company (a guild of which the writer is a Liveryman) appears to have existed in an early form as far back as A.D. 1365, that is, in the reign of Edward III. The Armourers and Brasiers Company was granted a charter in 1453 by Henry VI, but long before this it can be proved that it was in existence, since the guild possessed a Hall in 1428, and the Company claim an antiquity at least as ancient as the beginning of the 14th Century. The guild of the Blacksmiths claims by prescription to have been incorporated in the reign of Edward III in 1325, and the first charter was granted to the Company by Queen Elizabeth in the year 1571, which incidentally united the Blacksmiths with the ancient guild of the Spurriers. The Carpenter's Company received its charter from Edward IV in 1477, but the guild was in existence at an earlier period and, in fact, its Hall was begun in 1429 and gradually completed, while the Shipwrights' Company first appeared in the form of a guild as early as 1428, and there is a presumption in favour of it having existed by prescription for some time before that period. In 1661 it claimed to have had a corporate life of 400 years, hence the date of its foundation would be about the middle of the 13th Century. Its Charter of Incorporation was granted by James I in 1605. Nor must we forget the Hammermen of Glasgow, a body which dates back to the Middle Ages. These companies continue to take an active interest in their crafts, distributing their ample funds in prizes and grants to students, and endowments of professorial chairs at colleges and universities.

However, we will leave the Guilds and come to the Royal Society of London, which dates from the seventeenth century, being granted a Royal Charter in 1662 by "Carolus Secundus Rex" whose interest in the Society led him to seek its advice on at least four scientific questions; it was endowed with Chelsea College and lands by him. The terms couching the preface of the Royal Charter are noteworthy as the following translation shows:—

> "We have long and fully resolved with Ourself to extend not only the boundaries of the Empire, but also the very arts and sciences. Therefore We look with favour upon all forms of learning, but with particular grace We encourage philosophical studies, especially those which by actual experiments attempt

either to shape out a new philosophy or to perfect the old. In order, therefore, that such studies, which have not hitherto been sufficiently brilliant in any part of the world, may shine conspicuously amongst Our people, and that at length the whole world of letters may always recognize Us not only as the Defender of the Faith, but also as the universal lover and patron of every kind of truth:

Know ye that We, of Our special grace and of Our certain knowledge and mere motion, have ordained, established, granted, and declared, and by these presents for Us, our heirs, and successors do ordain established, grant, and declare, that from henceforth for ever there shall be a Society, consisting of a President, Council and Fellows, which shall be called and named The Royal Society; And for Us, our heirs, and successors We do make, ordain, create, and constitute by these presents the same Society, by the name of the President, Council, and Fellows of the Royal Society, one body corporate and politic in fact, deed and name, really and fully, and that by the same name they may have perpetual succession;"

Of interest too in the charter is the election of the Royal Society's first president:—

"Our very well-beloved and trusty William, Viscount Brouncker, Chancellor to Our very dear consort, Queen Catherine to be and become the first and present President, and to continue in this office until the feast of Saint Andrew next (if he shall so long live) and till another out of the Council be chosen and sworn."

Amongst other Presidents of the Royal Society have been Sir Christopher Wren, Samuel Pepys, Sir Isaac Newton and Sir Humphry Davy, whose first miner's safety lamp is still in the possession of the Society. It was invented in 1815, simultaneously with George Stephenson's safety lamp. The Royal Society was founded primarily for the advancement of pure science but it embraces the fundamentals of engineering practice and ranks first amongst the British learned societies.

Another society of broad scope is the Royal Society of Arts (1754) which has encouraged various branches of art and manufactures with its awards. Its Repository of Inventions, consisting of mechanical devices which had won the Society's awards, was first held in 1761 and may be regarded as the parent of all great exhibitions. In time these shows so overcrowded the Society's Rooms that its President, the Prince Albert (Consort of Queen Victoria), called a meeting in 1849 at which the Great Exhibition of 1851 was conceived.

Yet one more society of wide scope is the British Association for the Advancement of Science (1851) which has a special Section (G) for Engineering. The origin of the British Association may be traced to the condition of Britain after the Napoleonic Wars, when applied science fell into disrepute and Professor Charles Babbage of Cambridge published his "Reflections on the Decline of Science in England" (1830). This book was reviewed by Sir David Brewster, who appears to have been stirred to take steps which led up to the formation of the British Association, whose members you may remember, have visited Canada on several occasions.

In Scotland, the Royal Society of Edinburgh was established in 1783 from an older foundation, the Philosophical Society of Scotland, which had already been in existence for many years. Its wider boundaries admitted to its fellowship men of letters such as Sir Walter Scott, who was President in 1832. Chemistry, medicine and engineering are also represented on its roll.

The oldest purely engineering society is the Society of Civil Engineers (Smeatonian) founded in 1771, now a dining club of exclusive character at which eminent members of the profession foregather to perpetuate the memory of their founder.

The Institution of Civil Engineers, founded in 1818, and granted a Royal Charter by George IV in 1828, claims priority of the British engineering societies by seniority of foundation and catholicity of aim—the term "civil" being interpreted in its wider sense to embrace all forms of engineering other than "military," but recently this definition has been extended further to include officers of the fighting services, provided their engineering qualifications are satisfactory. "The art of directing the great sources of power in nature to the use and convenience of man" is indeed a noble objective, and one has only to glance through the voluminous Proceedings of this Institution to be assured of the fulfilment of its aims.

Thomas Telford (who became its first president in 1820) has left a tradition seeking perpetuation, and today we are justly proud to have with us the present president —Sir Alexander Gibb—his companion in thought, and by profession his lineal descendant.

The library of the Institution of Civil Engineers contains 61,000 volumes—its archives a treasury of knowledge—and the ample Proceedings give an account of almost every engineering work of importance. "Engineering Abstracts" of foreign technical literature are prepared by a committee of experts, and are available to the profession.

The Institution house in Great George Street has recently been completed by the addition of the west wing, which enhances its external appearance and adds to its dignity. Mr. James Miller, F.R.I.B.A., its architect, is also the designer of the adjacent wing of the building of the Institution of Mechanical Engineers.

A former President of the Institution told the writer that it was his endeavour to make the status of a Member of the Institution of Civil Engineers as high as that of a King's Counsel, and the Associate Membership equivalent to a Junior Counsel on admittance to the Bar. Whether this has been attained is debatable, but the practical and theoretical qualifications required are most exacting, and the status maintained from generation to generation.

Next in seniority among the Founder Institutions of the Engineering Joint Council is the Institution of Mechanical Engineers, which was founded at a meeting of leading members of the profession in Birmingham in 1847, and incorporated in 1878. It received a Royal Charter from King George V in 1930, which set forth the objects for which the Institution is constituted as follows:—

(*a*) To encourage invention and research in matters connected with mechanical engineering and, with this object, to make grants of money or books or otherwise to assist such inventions and research.

(*b*) To hold meetings of the Institution for reading and discuss communications bearing upon mechanical engineering or the application thereof, or upon subjects relating thereto.

(*c*) To print, publish and distribute the proceedings or reports of the Institution or any papers, communications, works or treatises on mechanical engineering or its application, or subjects connected therewith.

(*d*) To co-operate with Universities, other Educational Institutions and public Educational Authorities for the furtherance of Education in Engineering Science or Practice.

(*e*) To do all other things incidental or conducive to the attainment of the above objects, or any of them.

George Stephenson, "Father of Railways," was elected the first president, and generously gave £100 to the funds, taking an active interest in the new body, and reading papers himself. On his death in 1848, Scott Russell wrote of him:—"In our late president, England has lost one of her most distinguished men, the world one of its great benefactors."

His son, Robert Stephenson, was the next in the chair, and other famous presidents in early days were Sir William Fairbairn, Sir Joseph Whitworth, Lord Armstrong, Robert Napier and Sir William Siemens. The Institution of Mechanical Engineers moved from Birmingham to London in 1877, and for years was allowed the the use of the Institution of Civil Engineers' hall for its meetings. Afterwards, it built its own house at Storey's Gate in St. James's Park, and there it has repaid the debt by lending its accommodation for meetings of many of the more recently formed institutions, among which are the Institutions of Gas Engineers, Automobile Engineers, Locomotive Engineers, and Production Engineers.

Accommodation at the Institution of Mechanical Engineers comprises a well-equipped meeting hall (recently oak-panelled), council and committee rooms, reading room, and a refreshment room with walls and floor lined with marble. The library (with its three annexes and two galleries) renders practical service to the members. This will be evident when it is mentioned that over 4,000 technical books per year are lent, and 1,000 searches for specialized information are made. In addition, a list of latest works added is printed monthly in the Journal, with annotations in many cases. There is also a reading room where 350 current periodicals are exhibited.

The monthly Journal contains short summaries of papers to be discussed, particulars of forthcoming meetings, examinations, and other announcements. The principal publication of the Institution of Mechanical Engineers is of the Proceedings which contain the papers and discussions. They are issued in three volumes a year, and have been printed in an unbroken sequence from 1847. Many of these papers represent the acquisition of new knowledge and are not a mere chronology of work already accomplished.

Among other activities are the examinations held twice annually at home and overseas for Associate Members, Graduates and Students. There is, in addition, a scheme of National Certificates in Mechanical Engineering awarded at 168 technical colleges throughout Great Britain and Northern Ireland by the Institution, in conjunction with the respective Government Departments of Education. An important feature of the scheme is the fact that the control or oversight of the examinations (in so far as approval of the question papers and scrutiny of the marking of the answers is concerned) is exercised by Assessors, who are Members of the Institution, and are appointed by the Institution in conjunction with the Board of Education, or other Government Departments. The Principal of the School, or other local official, acts as examinations' officer, and due regard is given to the work done by the students in the class-room, in the laboratory and at home. In no case is the entity of any approved school or college endangered by entering candidates for these examinations —on the contrary, though insisting on a high National standard, the scheme is intended to foster local "esprit de Corps" and bring home to the many centres throughout the country, privileges which have hitherto been restricted to a few. The approved colleges do not find their activities curtailed in any way, but on the contrary receive the benefits resulting from contact with the Institution and the Board of Assessors, and the scheme is a great incentive to students to follow co-ordinated courses of instruction, rather than to attend isolated classes. Many students now follow these courses for six or seven years, or even longer, and obtain endorsements in additional subjects including those concerned with Workshop Organization and Management. The standard of the Higher National Certificate is that of an engineering degree in individual subjects. A student who has gained this certificate is allowed a considerable measure of exemption from the Associate Membership Examination of the Institution, in some cases sufficient to satisfy all the Institution's educational requirements.

The Institution of Electrical Engineers, the Institution of Naval Architects, the Institute of Builders, and the Institute of Chemistry also conduct schemes of National Certificates in their respective subjects; whilst the Institution of Automobile Engineers, the Royal Aeronautical Society, and the Institute of British Foundrymen co-operate with the Institution of Mechanical Engineers by endorsing its National Certificates where candidates have also taken their special subject.

Research has been in the forefront of the work of the British engineering Institutions, and more particularly of the Institution of Mechanical Engineers, for over half a century. The results of the investigations financed by them are recorded in the various proceedings and transactions. The progress of engineering technique, stimulated by the developments in other fields such as in metallurgy, and by inventions such as in new forms of locomotion, is maintained only by continuous attention to means of improvement, and by experimental research directed to the elucidation of phenomena and the rationale of new processes. It is clear that the principles of research must necessarily be abundantly recognized and employed in the newer branches of engineering as, for example, in the development of wireless communication and of aviation, progress in which has been so spectacular. It is perhaps not quite so manifest in the development of mechanical engineering. Nevertheless, it is true that the march of invention, the increasing severity of competition, and the complexity of modern civilization, cause the engineer constantly and tirelessly to pursue scientific investigations to enable him to satisfy the increasingly exacting demands made of him. The Institutions have been in the van of such developments and can point proudly to a list of researches all of which at the time they were in progress satisfied an urgent need for new knowledge and many of which, to this day, have left their mark in the stating of basic scientific principles. This important work is still being carried out by the Institutions and since the war, the Privy Council have set up a special Department of Scientific and Industrial Research, and have encouraged the industries themselves to elucidate their own specific problems, by the establishment of many British Industrial Research Associations initiated by large grants of public money, but continued with more and more support from their respective industries as their worth becomes known and appreciated.

The Institution of Mechanical Engineers has over 12,000 members, having practically doubled its membership since the immediate post-war period in spite of, or perhaps it should be said on account of, the increasingly high standard of admission. It has nine local branches in Britain, one in South America, and one in China, also several Graduates' Sections for the younger men. These local branches which began to be established in 1920 as an activity of the Institution, have become important features in its corporate life. They are made up of the members of all classes of the Institution resident in the districts they cover, and hold series of meetings at some convenient centre or centres under arrangements made by Branch Committees (both of Corporate Members and of Graduates and Students) elected by the members of the Branch. Important papers which have been read at General Meetings in London are frequently repeated at local branch meetings, and the resulting discussions embodied in the Proceedings, while papers of local interest are generally read at local branch meetings only. It occasionally happens that a paper of first-rate importance originates at a local branch meeting and, in this respect, as well as through increased membership as a result of such local activities, the branches act as feeders to the general life of the Institution. The work of the local branch is carried out voluntarily, and the brunt of it naturally falls on the honorary secretary, while the chairman for the time being is ex officio a member of the Institution's Council, and brings his own contribution to the work of that body. In addition, there are advisory Committees or Honorary Corresponding Members in the Dominions. The Canadian Advisory Committee consists of the following:—

Montreal—Mr. H. H. Vaughan, M.E.I.C.
Toronto—Professor E. A. Allcut, M.E.I.C.
Halifax—Engineer Commr. F. H. Jefferson, R.C.N.
Winnipeg—Mr. F. E. Collinson.
Vancouver—Major G. A. Walkem, M.E.I.C.

The third of the Founder Institutions of the Engineering Joint Council is the Institution of Naval Architects founded in 1860, and later came the Institution of Electrical Engineers (originally the Society of Telegraph Engineers and Electricians (1871) which is numerically the largest Institution, its membership amounting to over 16,000), and many specialized or local associations so that there are now over one hundred engineering societies with a total membership of 100,000. It has been estimated by Sir Alexander Gibb that one seventh of the working population of Britain is connected in one way or another with engineering. Other prominent institutions which should be mentioned are:—

The Society of Engineers (1854)
The Institution of Gas Engineers (1863)
The Royal Aeronautical Society (1866)
The Iron and Steel Institute (1869)
The Institution of Municipal and County Engineers (1872)
The Institution of Royal Engineers (1875)
The Institute of Marine Engineers (1889)
The Institution of Mining and Metallurgy (1892)
The Institution of Water Engineers (1896)
The Institution of Heating and Ventilating Engineers (1897)
The Institution of Automobile Engineers (1906)
The Institute of Metals (1908)
The Institution of Structural Engineers (1908)
The Institution of Locomotive Engineers (1911)
The Institution of Production Engineers (1921)
The Institution of Chemical Engineers (1922)

It will be seen that a number of these have already reached their Jubilee, and others are approaching that occasion.

Amongst these bodies is one, the Institution of Mining Engineers, which is a Federation of a number of local associations, each of which retains its own name, but its papers are published in the Transactions of the parent body. Their members are also members of the parent body, which possesses no members apart from those of its constituents.

Another society, the Junior Institution of Engineers (1884), has paid special attention to the development of social intercourse amongst its members, and the help and encouragement of young engineers; and there is the Newcomen Society (1920) which is devoted solely to the fascinating study of engineering history.

Ireland, Scotland and Wales, also have their own national societies, namely, the Institution of Civil Engineers in Ireland (1835) with the younger but virile Belfast Association of Engineers (1892) in Northern Ireland, the Institution of Engineers and Shipbuilders in Scotland (1857), and the South Wales Institute of Engineers (1857). Then there are bodies which are identified with particular districts, such as, the North of England Institute of Mining and Mechanical Engineers (1852) (a constituent of the Institution of Mining Engineers); the North-East Coast Institution of Engineers and Shipbuilders (1854), and the West of Scotland Iron and Steel Institute (1892).

The chief manufacturing towns have their own local societies, such as the Manchester Association of Engineers (1856), the Liverpool Engineering Society (1875) and many others.

It is thought by some that there are too many societies, and indeed, the subjects in which the younger societies specialize are usually branches of general engineering. Most of these, however, cater for those whose practical training or educational qualifications do not, in many cases, reach the general standard of knowledge required by the by-laws and examinations of the senior Institutions, also they allow of more frequent discussion of papers on their specialist subjects than is possible with a body representative of broader interests. Proposals for the affiliation of the younger institutions have so far been unsuccessful. To some extent, the formation of sections solves this problem; for instance, in the Institution of Mechanical Engineers there is an Education Group, an Internal Combustion Engine Group, and a Steam Group, each run by a small committee and each with its own series of meetings, mostly of an informal character, but sometimes consisting of the discussion of a symposium of printed papers dealing with current developments in its particular sphere.

There is a tendency in British societies to hold, in addition to their usual discussions, regular informal meetings at which, instead of a printed paper being presented, a short introduction to a subject is given, and then free and unreported discussion is allowed.

The leading Institutions possess Royal Charters which entitle their corporate members to style themselves "Chartered Civil Engineer," "Chartered Mechanical Engineer," etc. All these bodies are governed by by-laws made under the charters and by councils elected by the corporate members. The councils necessarily have to appoint numerous committees to deal with the various activities, such as Publications and Library, Finance, Research, Examinations, etc.

Social activities, though subservient to technical matters, are not neglected, visits to works, dinners, conversaziones and summer meetings being held regularly. These summer meetings are enjoyable functions, and have formed part of the Institution of Mechanical Engineers' activities since 1856. They provide opportunities for members to meet socially, and visits are made to important engineering works. Visits have been paid to most of the principal cities in the British Isles, and several of the meetings have been held overseas, notably in Europe, the United States and Canada. You may remember the Institution of Mechanical Engineers' visit to Canada in 1932, and very pleasant are the visitors' memories of your kind entertainment on that occasion.

Useful joint efforts are made and there is substantial collaboration amongst the societies, such as the Marine Oil-Engine Trials carried out by the Institution of Mechanical Engineers with the co-operation of the Institution of Naval Architects, the Institute of Marine Engineers and the Admiralty. The British Standards Institution was brought into being with the support of the leading engineering bodies, and still receives financial help from several of the Institutions. The Engineering Joint Council established in 1922 consists of representatives from four Founder Institutions and four co-opted Institutions, and considers matters generally affecting the profession.

Engineering in Great Britain is not a closed profession—it may be practised by anyone, for there is no registration of engineers. However, it may be regarded as a semi-closed profession, since it is advisable for any member of it who aspires to some degree of standing, to join one of the few leading Institutions and thereby gain the necessary status which this confers, besides keeping in touch with both the technical and administrative developments of his profession. The peculiar position of our great engineering Institutions in conferring special status is not always understood abroad, where an engineering degree, coupled with government recognition, is the acknowledged qualification for an engineer. Ours is a typically British system which has grown up with the development of engineering science and practice, and possesses an elasticity which enables it to include engineers of very diverse types of training and education, who are capable of maintaining our high traditions.

This résumé would not be complete without some reference being made to the work accomplished by the engineering societies of the students at the universities and colleges throughout the country. Among these, King's College Engineering Society of London, founded in 1847, may be regarded as the oldest, and has been the training ground of several presidents of the senior Institutions.

In conclusion, the writer would like to emphasize the quiet and unobtrusive work which is being done year by year by the learned societies all over the world. We are working harmoniously for the betterment of mankind—and progrcss, though gradual, is cumulative.

# APPENDIX

Copy of Illuminated Loyal Address on vellum presented to H.M. KING GEORGE VI on his Coronation on 12th May 1937, under Seal of the Institutions and signatures of President and Secretary of each society.

To His Most Excellent Majesty,
King George VI.

MAY IT PLEASE YOUR MAJESTY

We, on behalf of the members of the principal Engineering Institutions and Societies in the United Kingdom of Great Britain and Northern Ireland, desire to tender on the occasion of Your Coronation our heartfelt congratulations and to offer our earnest wish that Your Reign may be long, prosperous and peaceful.

Your Majesty has always evinced a deep interest in the Institutions that exist for the advancement of engineering science and for the better utilization of the forces of nature for the benefit of mankind. In the course of the services which You rendered as Duke of York during the lifetime of Your much beloved Father, His late Majesty King V, You have been brought into direct contact with workshops, with mines and with works of engineering construction, wherein the art of the Engineer and the manual skill of the workman have combined to supply many of the needs of modern civilization.

In the assurance of Your knowledge of and close interest in the work on which we are engaged, we beg leave humbly to express to Your Majesty and to Her Majesty Queen Elizabeth our loyalty and support in the onerous duties consequent upon Your accession to the Throne, and we pray that Almighty God may bestow upon Your Majesties health and strength to bear these responsibilities, and happiness in the knowledge of the devotion of Your people.

List of Signatures:—

The Institution of Civil Engineers:
Alexander Gibb, President; H. H. Jeffcott, Secretary. (L.S.)

The Institution of Mechanical Engineers:
J. E. Thornycroft, President; Magnus Mowat, Secretary. (L.S.)

The Institution of Naval Architects:
Stonehaven, President; C. V. Boys, Secretary. (L.S.)

The Institution of Gas Engineers: Stephen Lacy, President;
J. Terrace, Hon. Secretary, J. R. W. Alexander, Secretary. (L.S.)

The Royal Aeronautical Society:
H. E. Wimperis President; J. Laurence Pritchard, Secretary. (L.S.)

The Iron and Steel Institute:
H. C. H. Carpenter, President; K. Headlam-Morley, Secretary. (L.S.)

The Institution of Electrical Engineers: H. T. Young, President;
Frank Crawter, Member of Council; P. F. Rowell, Secretary. (L.S.)

The Institution of Municipal and County Engineers:
D. Edwards, President; C. W. Scott-Giles, Secretary. (L.S.)

The Institute of Marine Engineers:
Stephen J. Pigott, President; B. C. Curling, Secretary. (L.S.)

The Institution of Mining Engineers:
C. Augustus Carlow, President; C. McDermid, Secretary. (L.S.)

The Institution of Mining and Metallurgy:
Robert Annan, President; C. McDermid, Secretary. (L.S.)

The Institution of Water Engineers:
Neil J. Peters, President; A. T. Hobbs, Secretary. (L.S.)

The Institution of Automobile Engineers:
J. S. Irving, President; Brian G. Robbins, Secretary. (L.S.)

The Institute of Metals:
William R. Barclay, President; G. Shaw Scott, Secretary. (L.S.)

The Institution of Structural Engineers:
C. H. Fox, President; R. F. Maitland, Secretary. (L.S.)

The Institution of Chemical Engineers: Wm. Cullen, President;
(A. J. V. Underwood, M. B. Donald,) Joint Hon. Secretaries. (L.S.)

# THE ENGINEERING JOURNAL

THE JOURNAL OF
THE ENGINEERING INSTITUTE OF CANADA

"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."




VOLUME XX  AUGUST, 1937  No. 8

## Air Service - Transatlantic - Transcontinental

The successful out and home flights across the North Atlantic of the British Imperial Airways flying boat *Caledonia*, and the Pan American *Clipper III*, which have just been completed, were the first of a series to be conducted by the experts of the two lines in order to gain experience in the operation of the aircraft on that route, and to test the airway facilities, and those navigation aids and meteorological services whose completeness and efficiency are so necessary for the maintenance of a regular transatlantic service on a commercial basis. The service is to be operated by a company with which the governments of Great Britain, Canada, the Irish Free State and the United States will be associated, an arrangement which is an excellent example of international co-operation.

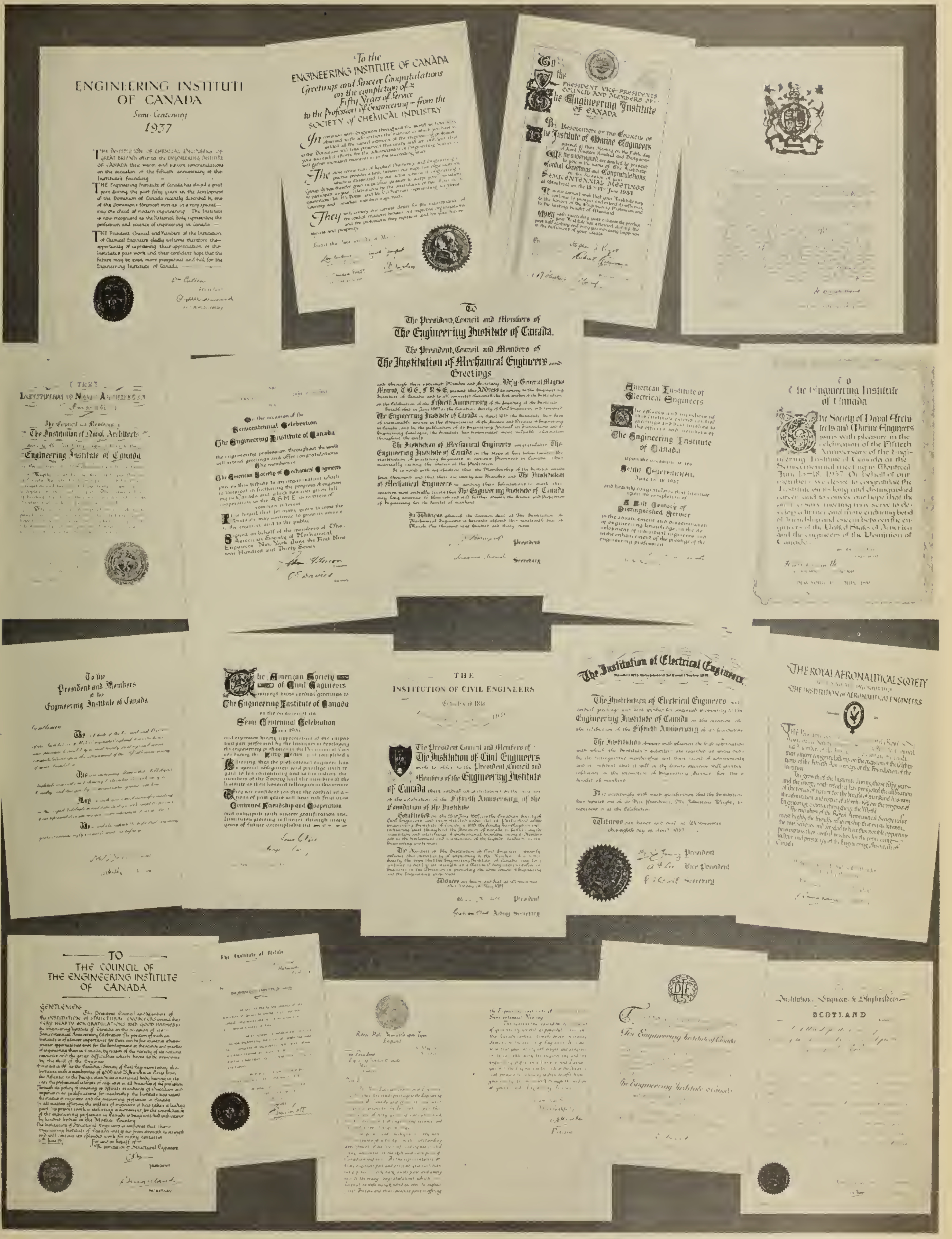
While these preliminary transatlantic crossings are being made, another Imperial Airways flying boat, the *Centurion*, has just flown the 7,200 miles from Southampton to Durban, inaugurating the new airmail services between England and South Africa. These happenings are only a few of the steps which are being taken towards the building up of a chain of air communication which will ultimately be completed by a transpacific air service between Canada and Australia and New Zealand, for which international co-operation is proposed on a basis somewhat similar to that now being arranged for the transatlantic services.

Just three weeks before the *Caledonia* made its fifteen hour flight from the mouth of the Shannon to Botwood, Newfoundland, there was presented at the Semicentennial meeting of The Institute a paper on the North Atlantic Air Service, which we publish in this issue of the Journal. In this monograph the author makes a critical examination of the whole problem of the North Atlantic crossing, and studies the conditions under which it is possible to insure a regular air service on that route for mails and passengers. In doing so Mr. Parkin deals with potential traffic, the weather conditions to be met with, the necessary organization both on the ground and in the air, the types of aircraft available, and other essential points. He gives valuable historical data as to previous achievements. As regards the recent flights it is interesting to note that the eastward and westward journeys of both aircraft gave results closely in accord with those outlined by Mr. Parkin.

Speaking in the discussion on the paper, the President of the Royal Aeronautical Society suggested that for such work in the future a considerable increase in the size of the aircraft was probable; in fact he looked forward to flying boats ten times the weight of the eighteen ton *Caledonia*. Mr. Wimperis, who is on his way to Australia to advise the Australian Government on aeronautical matters, believes that the provision of suitable engine equipment for such large aircraft is the only remaining difficulty which hinders their adoption. He referred to the possibilities of refueling in the air, a scheme which is being explored with very promising results. As an alternative, the use of a carrier machine will be tried, releasing the operating plane at an elevation. Like catapult launching, these methods are intended to avoid the limitation of payload by the large amount of fuel that must be carried on a transatlantic flight. Mr. Wimperis was quite optimistic as to the possible traffic available, particularly as regards first class mail.

In thanking Mr. Parkin for his paper, the Minister of Transport remarked that Canada would be a partner as to 24½ per cent in the commercial enterprise that will follow the experimental North Atlantic flights. In a further address which he delivered at the Semicentennial Dinner at Ottawa, Mr. Howe drew a striking picture of the development of aviation in Canada, pointing out that it presents features of special interest, since its main lines have been decided by the topographical and climatic characteristics of the Dominion and the location of its natural resources, rather than by the distribution of its population. In contrast with countries whose aviation systems have been based on military requirements, or on the need for interurban passenger services, our flying services have to meet the requirements of exploration, the rapid mapping of large areas of sparsely inhabited country, the transport needed by a great mineral industry at points widely scattered over undeveloped territory, and last, but not least, the establishment of a regular trans-Canada mail and passenger service. He gave an impressive account of the progress which has already been made in the provision of landing fields across the continent, their equipment with the necessary aids to navigation, and the training of the large ground staff required. It is not very difficult to obtain suitable aircraft and flying personnel for such a transcontinental service as is contemplated, but it is a huge undertaking to equip and organize a route nearly four thousand miles in length, involving day and night flying, and passing over wilderness and mountains as well as settled lands. In such a case success can only be secured by employing the most modern methods in weather forecasting, radio service, airport lighting, and ground organization.

It is evident that Mr. Howe fully realises the importance to Canada of this newest branch of transport. He is well aware of the magnitude of the task it presents; his personal interest in air travel has done much to awaken public appreciation of what has already been done and what remains to be accomplished in establishing regular transcontinental communication over Canadian territory.




**Official greetings from Sister Societies presented at the Semicentennial Celebrations June, 1937.**

## Joint Meeting of the American Society of Civil Engineers and the Engineering Institute of Canada

**Boston—October 6th, 7th and 8th, 1937**

Three years ago the American Society of Civil Engineers held its Annual Convention in Vancouver, concurrently with a Western Professional Meeting of The Institute. The headquarters of both bodies were in the same hotel; joint sessions and discussions were held; members of both organizations participated in the various social events and excursions; many old acquaintanceships were renewed, and many new friendships formed. The happiest results followed.

The existing cordial relations between the two organizations will be further promoted by the action of the Board of Direction of the American Society of Civil Engineers in inviting the Institute to join with the Society in their Fall meeting in Boston this year. This cordial invitation was gratefully accepted by The Institute Council in the confident expectation that a large contingent of our members, particularly from the east, will take this opportunity of visiting New England and taking part in the joint proceedings.

The outline programme, published elsewhere in this issue, contains many attractions. The list of speakers includes such outstanding men as the Presidents of Harvard University and the Massachusetts Institute of Technology. The professional papers contributed by the members of the Society cover a wide range of topics, among which the rapidly developing science of Soil Mechanics will be a leading feature. The Canadian papers, fewer in number, deal with three major Canadian engineering projects.

Boston and its vicinity afford a delightful setting for the social functions and visits. Many good highways lead to Boston—adequate railway arrangements will be provided—Boston hotels are excellent—and Canadians will be heartily welcomed.

## The Engineering Institute of Canada Prize Awards 1937

Eleven prizes known as "The Engineering Institute of Canada Prizes" are offered annually for competition among the registered students in the year prior to the graduating year in the engineering schools and applied science faculties of universities giving a degree course throughout Canada.

Each prize consists of twenty-five dollars in cash, and having in view that one of the objects of The Institute is to facilitate the acquirement and interchange of professional knowledge among its members, it has been the desire of The Institute that the method of award should be determined by the appropriate authority in each school or university so that the prize may be given to the student who, in the year prior to his graduating year, in any department of engineering has proved himself most deserving as disclosed by the examination results of the year in combination with his activities in the students' engineering organization, or in the local branch of a recognized engineering society.

The following are the prize awards for 1937:—

| | |
|---|---|
| University of British Columbia | Charles H. Davenport |
| University of Alberta | Frederick Johnston Heath |
| University of Saskatchewan | G. N. Moore |
| University of Manitoba | Frank A. P. Athey |
| University of Toronto | Ervine W. Smith |
| Queen's University | R. D. Ramsay |
| Royal Military College | Ernest Roy Hyman, S.E.I.C. |
| McGill University | Pierre A. Duchastel de Montrouge, S.E.I.C. |
| Ecole Polytechnique | Guy Beaudet, S.E.I.C. |
| University of New Brunswick | Gerald A. Campbell, S.E.I.C. |
| Nova Scotia Technical College | R. P. Hudson |

## PERSONALS

Lieut. Colonel E. V. Collier, M.E.I.C., has been appointed general manager of Simplifix Couplings, Limited, manufacturers of compression joints, London, England. Colonel Collier was formerly with the Anglo-Persian Oil Company Limited, at Abadan, Persian Gulf.

Herve A. Gauvin, A.M.E.I.C., for the past three years divisional engineer for the provincial Department of Roads, Quebec, has resigned to accept the position of assistant general superintendent of Belanger Limited, Montmagny, Que.

Major M. Barry Watson, A.M.E.I.C., has been appointed director of the Department of Military Studies in the University of Toronto, vice Brig.-Gen. G. S. Cartwright, retired.

While Major Watson is a well known consulting engineer in Toronto and vicinity, and is continuing in private practice as such, he has been closely connected with military affairs and during recent years has been active in the University of Toronto, Canadian Officers Training Corps.

Keith Dixon, A.M.E.I.C., has recently received an appointment with the Esquimalt and Nanaimo Railway at Victoria, B.C. Prior to securing this position Mr. Dixon was for the past few years with the Ontario Department of Northern Development as divisional and resident engineer in charge of the location and construction of highways. From 1923 until 1931 he was with the construction department of the Canadian Pacific Railway Company.

Commander (E) A. C. M. Davy, R.C.N., A.M.E.I.C., attached to H.M.C.S. *Stadacona* at H.M.C. Dock-yard Halifax, N.S. has recently been promoted from the rank of Lieut.- Commander to that of Commander (E). Commander Davy, is a graduate of the Royal Naval College of Canada and The Royal Engineering College, Devonport, England.

C. D. Schultz, Jr.E.I.C., a graduate from the University of British Columbia, 1931, in Forest Engineering has recently been appointed British Columbia Timber Commissioner to the West Indies with headquarters at Kingston, Jamaicia.

R. E. McMillan, A.M.E.I.C., is now located with the Canadian Industries Ltd., Montreal. Mr. McMillan, who graduated from McGill in 1926 in electrical engineering, was previously plant engineer for the British Rubber Company of Canada, Montreal.

John Clancy, A.M.E.I.C., who graduated from the Nova Scotia Technical College in 1928, is now with the Canadian Pacific Railway Company Communications Engineering Department in connection with Eastern Lines Mr. Clancy was previously with the Northern Electric Company, in their Telephone Systems Engineering Department.

C. E. Frost, A.M.E.I.C., recently received an appointment on the engineering staff of the Bell Telephone Company, Canada, Montreal, Mr. Frost graduated from McGill University in 1931, and was previously assistant engineer with the National Harbours Board, Montreal. He is chairman of the Junior Section of the Montreal Branch of The Institute.

H. A. Thompson, A.M.E.I.C., has been appointed paper mill engineer for the Merritt, Chapman and Scott Corporation of New York City. This firm is at the present time constructing sulphate mills at Savannah, Georgia, Fernandina, and Jacksonville, Florida. Mr. Thompson, graduated from the University of Saskatchewan in 1927 and since that time has had extensive experience in the designing and construction of pulp and paper mills. For the past few years he has been maintenance engineer with the Fraser Companies at Edmondston, N.B.

# The Eighth Plenary Meeting of Council

The Eighth Plenary Meeting of the Council of The Institute was convened at the Windsor Hotel, Montreal, on Monday, June 14th, 1937, at ten o'clock a.m., with President G. J. Desbarats in the chair, and the following members of Council present: Past-Presidents E. A. Cleveland, G. H. Duggan, J. M. R. Fairbairn, F. A. Gaby, O. O. Lefebvre, C. H. Mitchell, F. P. Shearwood, Julian C. Smith, J. G. Sullivan, H. H. Vaughan and George A. Walkem; Vice-Presidents R. L. Dobbin (Province of Ontario), H. S. Carpenter (Western Provinces), J. A. McCrory (Province of Quebec), and H. W. McKiel (Maritime Provinces); Councillors R. J. Askin (Lakehead), W. E. Bonn (Toronto), R. W. Boyle (Ottawa), P. H. Buchan (Vancouver), H. J. A. Chambers (Border Cities), H. Cimon (Quebec), A. B. Crealock (Toronto), J. B. D'Aeth (Montreal), T. H. Dickson (Moncton), R. M. Dingwall (Edmonton), A. Duperron (Montreal), A. B. Gates (Peterborough), B. Grandmont (Three Rivers), A. K. Hay (Ottawa), F. S. B. Heward (Montreal), A. C. Johnston (Saguenay), E. P. Muntz (Hamilton), E. P. Murphy (Niagara Peninsula), F. Newell (Montreal), E. J. Owens (Saint John), E. A. Ryan (Montreal), R. A. Spencer (Saskatchewan), J. A. Vance (London), and Treasurer J. L. Busfield. There were also present by invitation: Mr. C. C. Kirby, Saint John, President of the Dominion Council of Professional Engineers, Mr. H. J. Crudge, Moncton, N.B., President of the Association of Professional Engineers of New Brunswick, and Mr. H. L. Briggs, Secretary-Treasurer of the Winnipeg Branch of The Institute.

After welcoming the members of Council to the meeting, the President remarked that although the recent consolidation proposals had not been approved by the membership, there was no doubt that The Institute members as a whole felt that endeavours should be continued to arrange closer relations with the Professional Associations. The President was glad to welcome so many past-presidents, and also Mr. C. C. Kirby, the President of the Dominion Council of Professional Engineers.

Mr. R. A. Spencer then presented the report of the committee, consisting of himself and Messrs. J. L. Busfield and F. S. B. Heward, which had been appointed on May 28th, 1937, to report on the suggestions put forward by Mr. Spencer at the Council meeting on that date. After sketching the situation in Saskatchewan as a typical case, Mr. Spencer pointed out that the report now submitted recommended the formation of a Committee on Professional Interests, together with a number of provincial subcommittees to deal with salaries and remuneration, professional practice, junior engineers and public education respectively. It was also suggested that a special committee of a temporary nature be set up to investigate and report upon the membership and management of the Institute. The report further recommended the adoption by the Council of a resolution* stating the Council's willingness to negotiate with the Provincial Professional Associations along certain lines.

The report further proposed that steps should be taken leading to closer relations with other engineering organizations operating in Canada, and recommended the appointment of a committee to report on this point.

Past-President Julian C. Smith remarked that while all were agreed as to the desirability of closer relations with Professional Associations, he thought it would be wise to wait for a while before opening up so many important questions. He thought the more pressing matters named in the report should be dealt with first.

*The text of this resolution will be found on page 585 of the July issue of the Journal.

Past-President H. H. Vaughan observed that since 1918, when The Institute promoted the formation of the Provincial Professional Associations during his presidency, his views had changed. A condition had now been reached in which membership in the several Professional Associations endorsed a man's professional competence and therefore gave him a status somewhat similar to that resulting from corporate membership in The Institute, with the added advantage of a legal right to practise. In Mr. Vaughan's opinion recognition of professional standing was not one of the main objects of The Institute, which were the dissemination of professional knowledge, holding meetings to discuss engineering subjects, and bringing together men interested in engineering work so that they could exchange information and become acquainted with one another. Under these circumstances Mr. Vaughan was of opinion that general membership in The Institute should be thrown open to all men engaged in engineering work who desired to participate in The Institute's activities. This would leave to the Provincial Associations all questions relating to qualification to practise, and the activities of The Institute would be greatly strengthened by the admission of many whose co-operation in The Institute's work would be of great value, who hold important and responsible engineering positions but who cannot at present join The Institute as corporate members. This broadening of The Institute's constitution should be accompanied by a reduction in the fee to the general membership, and seniority and eminence in the profession should be recognized by the creation of a class of Fellows. The President thanked Mr. Vaughan for this expression of his views.

Mr. H. J. Crudge, representing the Association of Professional Engineers of New Brunswick, explained the situation existing there, and said that the New Brunswick Association was of the opinion that no benefit would be gained by entering into any specific agreement along the lines suggested at the present time. The Association would, however, co-operate in any further investigation into the subject.

Vice-President H. S. Carpenter said that in Saskatchewan younger members entering the profession tended to join the Professional Association rather than The Institute. He urged that the report of Mr. Spencer's committee should be implemented as soon as possible.

Mr. R. M. Dingwall thought that the Professional Associations needed a Federal organization which would be in contact with all of them. He could not understand the objection so often heard as to the duplication of fees; the total amount payable to an Association and The Institute was not large in relation to the services rendered.

Professor H. W. McKiel did not think any time should be lost in discussing matters with the Nova Scotia group. He hoped that a meeting of the joint committee which had been formed in Nova Scotia to consider the matter would be held very shortly.

Mr. Hector Cimon, in response to a request from the President, stated that in the view of the Corporation of Professional Engineers of Quebec a prime requisite for consolidation was that in the future, admission to corporate membership in The Institute in the province of Quebec should be limited to members of the Corporation. This view was also held by the Quebec Branch of The Institute.

Mr. P. H. Buchan observed that in British Columbia, having regard to the result of the recent ballot of The Institute, it was felt that the B.C. Association should go ahead with the development of their idea of the Dominion Council. Mr. Buchan explained the system in British Columbia, under which the younger men entering the profession were being drawn into the Association, so that in a short time there would be no engineers in British Columbia not registered, and many of them would not be interested in The Institute.

Mr. F. S. B. Heward had been glad to hear the favourable opinions expressed with regard to the report, and *moved* its adoption. His motion was *seconded* by Mr. R. J. Askin.

Past-President George A. Walkem was impressed by the difficulty of obtaining agreement among the Associations, and could not see how a definite amalgamation could take place between The Engineering Institute, a national body, and provincial bodies which had entirely different functions.

Dr. R. W. Boyle had no objection to the report but felt that it opened up a larger number of important questions than had seemed probable when the committee was appointed. He hoped that the decision upon its adoption would not be rushed.

At the President's suggestion, Mr. Kirby spoke. He pointed out that none of the Provincial Associations had suggested consolidation with The Institute, although they had on The Institute's invitation participated in negotiations to find some way in which The Institute could function as the head of the family of engineers in Canada. In view of the result of the recent ballot on the proposals which had followed, Mr. Kirby believed that the Associations were now strongly in favour of the continuance and development of the Dominion Council. Many engineers were surprised to find that The Institute membership had not backed up a measure recommended by The Institute's Committee on Consolidation, approved by a Plenary Meeting of the Council of The Institute last October, and endorsed by The Institute's general meeting last February. He believed that The Institute was now at a parting of the ways, and it was for The Institute to decide whether professional organization was to be carried out by the corporations in co-operation with The Institute, or separately from them.

Mr. H. J. A. Chambers, expressing the ideas of the Border Cities Branch, remarked that they had no objection to admitting members from Provincial Associations whose requirements equalled those of The Institute, but they did object to admitting those of any Association whose requirements did not reach this standard. They hoped some day to see a joint body, membership in which would qualify men to practise in any province of Canada.

At this point Mr. Heward asked permission to interrupt the debate. He pointed out that the Semicentennial Celebrations of The Institute would commence next day, and desired to move that the Council recognize its appreciation of the time and energy which Mr. J. L. Busfield had spent on the organization of these celebrations by authorizing the purchase of a suitable gift for him as a memento of the occasion. Mr. Heward's motion having been *seconded* by Mr. E. P. Muntz, was unanimously *carried*.

Mr. A. B. Crealock noted with regret that in the report under discussion the committees proposed seemed to have some duties which really belonged to the Associations, particularly in respect to questions relating to professional practice. Such matters, in his opinion, concerned the Dominion Council rather than the Engineering Institute. Mr. Crealock desired to urge that no recommendation of any of the committees proposed in the report should become effective unless endorsed by a Plenary Meeting of Council or approved by a majority of the Council on letter ballot. Could Mr. Heward's motion for the adoption of the report be amended to this effect?

It was *agreed* that a statement requiring such endorsation should accompany the report.

Mr. Heward pointed out that if the Provincial Subcommittees named in the report could co-operate with their respective Provincial Associations, the main Committee on Professional Interests could equally well co-operate with the Dominion Council. Failure to mention the Dominion Council in the report indicated no lack of respect for that body. If Mr. Crealock's views could be met by amending the report, Mr. Heward would be glad to see it done.

Professor McKiel inquired whether adoption of the report now under consideration would have any effect on the appointment of Mr. Fowler and himself to act on the committee functioning in Nova Scotia, and the President assured Professor McKiel that the arrangement in Nova Scotia would stand in any case.

The meeting adjourned at twelve fifty p.m. to reconvene at two fifteen p.m.

### Afternoon Session

Mr. H. L. Briggs, the Secretary of the Winnipeg Branch, attended by request, and sketched the situation existing in Winnipeg. The Manitoba Association and the Winnipeg Branch were on very friendly terms; in fact the Association had assisted the Winnipeg Branch financially to help the branch to carry on its technical and social functions. Mr. Briggs felt that the engineers in Manitoba were anxious for some action to be taken now in respect to the proposals for local consolidation which had been put before The Institute Council some two years ago.

Mr. J. A. McCrory remarked that the opinions so far expressed had been so divergent that he wondered how solutions to the various problems could be arrived at by such committees as were now proposed. The investigations contemplated in the committee's report were a heavy task and strong active working committees would be needed to obtain results.

Past-President E. A. Cleveland observed that many of the Professional Associations felt that the membership of The Institute should be confined to Association members. In his opinion there were many possibilities of improvement as to the usefulness of The Engineering Institute, and he hoped that the committees now proposed would be able to devise means by which the younger men in the Associations would form an attachment to a Dominion-wide body such as The Institute.

Mr. Kirby thought it most desirable that at this point The Institute Council should make a definite statement as to its policy. Is it desired to build up an Institute that is highly technical and professional, or is it desired to create a large body including men who may be technicians but who are not practising engineers? This uncertainty contrasted unfavourably with the definite aim of the Associations, namely, that all their members should be men recognized by law as competent engineers.

Mr. Spencer pointed out that this matter would naturally come before the Committee on Management and Membership, and he thought that before making such a pronouncement as that suggested by Mr. Kirby, the report of the Committee on Professional Interests should also be awaited.

After further discussion, the President put Mr. Heward's motion for the adoption of the report, and the motion was *carried* unanimously.

With reference to the personnel of the various committees proposed in the report, Mr. Spencer suggested that a nominating committee be appointed to bring in recommendations on this matter; this Nominating Committee was accordingly appointed as follows:

Dr. E. A. Cleveland, M.E.I.C., Chairman
H. S. Carpenter, M.E.I.C.
H. Cimon, M.E.I.C.
R. L. Dobbin, M.E.I.C.
J. A. McCrory, M.E.I.C.
H. W. McKiel, M.E.I.C.

Mr. Spencer asked whether the Council would think it desirable to appoint a separate committee to act in further negotiations with the Provincial Associations. The Nominating Committee would select the committee of three on Professional Interests; would select the councillor from each province to head the various subcommittees; would select the Committee on Membership and Management, and would select the special committee to report on the feasibility of closer co-operation with other engineering organizations.

After further discussion, the President pointed out to Dr. Cleveland that his committee's duties would also include the nomination of a committee to follow up negotiations with the Associations.

Professor McKiel desired to draw attention to the question of Institute administration at Headquarters. At the President's suggestion the Secretary withdrew from the meeting, and discussion followed on this matter, after which, on the *motion* of Professor McKiel, *seconded* by Mr. Muntz, a resolution of confidence in the Secretary was placed on record.

The Secretary, having returned, presented a report from the scrutineers as to the existence of information regarding the distribution of the recent vote on the amendments to the by-laws. Discussion followed, after which it was *moved* by Mr. Cimon that in future ballots of The Institute the ballots be sorted in such a way that the scrutineers can report how the vote went by provinces. Mr. Cimon's motion was *seconded* by Mr. Muntz. After further discussion, Mr. Cimon having accepted an amendment by Mr. Dingwall, that information as to a vote by provinces should be available only to Council, subject to their decision to publish if thought necessary, Mr. Cimon's motion was put to the meeting and *failed to carry.*

Following further discussion, on the *motion* of Mr. Crealock, *seconded* by Mr. W. E. Bonn, it was *resolved* that the statement of the scrutineers as presented at this meeting be received and published in the next issue of the Journal*.

Mr. Newell drew attention to the very strenuous work of Mr. Pitts and his Committee on Consolidation, which had continued during the past two years. He pointed out that that committee had had the difficult task of trying to devise a scheme which would bring together The Institute and the Professional Associations, and he *moved* that Council accord a very hearty vote of thanks to Mr. Pitts and the members of the recent Committee on Consolidation in recognition of their arduous work. Mr. Vance *seconded* Mr. Newell's motion and desired to add that thanks should be accorded to the Headquarters staff for the large amount of work they had carried on in connection with the work of the Committee on Consolidation.

The President pointed out that although the scheme prepared by Mr. Pitts and his committee had not met with the approval of the membership, their work was by no means lost. A vast amount of information had been gathered; wide interest was awakened in Institute affairs, and the sentiment of all sections of The Institute had been explored, the activities of the committee thus resulting in great benefit to The Institute. The motion was *carried* unanimously.

*This report is printed on page 589 of the July issue of the Journal.

Mr. McCrory *moved* a hearty vote of thanks to the scrutineers for their efficient work in canvassing the vote on the recent ballot on consolidation, and also moved that the ballot papers be now destroyed. Mr. Cimon desired to have the privilege of *seconding* Mr. McCrory's motion. The work of the scrutineers had been unusually heavy. The motion was *carried* unanimously.

In regard to the question of the award of the Sir John Kennedy Medal for the year 1937, it was *resolved*, on the *motion* of Mr. McCrory, *seconded* by Mr. Heward, that the matter be deferred to the next meeting of Council in the hope that other suggestions would come in.

It was noted that since the last meeting of Council a few additional suggestions had been received as to the subject for the Past-Presidents' Prize for the year 1937-1938, and, after discussion, it was decided that the subject should be "Stream Control in Relation to Drought and Floods."

The Secretary presented further correspondence in connection with an inquiry received from a member of the Border Cities Branch as to the ownership of plans prepared by engineers for municipalities. In this connection Mr. Buchan cited a case which had come before the British Columbia Courts some time ago, and kindly furnished information which the Secretary was directed to forward to the enquirer.

Dr. Boyle desired to draw attention to some points in connection with The Institute's organization. In his opinion, the provision in the by-laws for a quorum of five at Council meetings was anomalous, that quorum being only one-eighth of the Council. A quorum of a larger number would, of course, involve the payment of travelling expenses, and Dr. Boyle would suggest that the money now devoted to the holding of a Plenary Meeting each year should be used for the payment of councillors' expenses to ordinary Council meetings, with an increased quorum, preferably twelve. More meetings should be held outside of Montreal, preferably in succession in the various zones, so that the vice-presidents could preside. Dr. Boyle *moved* that this matter of the quorum of Council meetings should be referred to the new Committee on Membership and Management for study and report. The motion having been *seconded* by Mr. A. K. Hay, was put to the meeting and *carried.*

The meeting adjourned at six twenty-five p.m., to reconvene at five thirty p.m. on Tuesday, July 16th, 1937.

At the adjourned meeting on July 16th, Dr. Cleveland presented the report* of his committee, which recommended the appointment of the members of the various committees, and also advised that the main Committee on Professional Interests should be authorized to act in any negotiations with the Professional Associations.

On the *motion* of Dr. Cleveland, *seconded* by Mr. Dobbin, these recommendations were *approved.*

Mr. Chambers desired to draw attention to the work which might be done by the proposed Committee on Professional Interests as regards public education, by which he meant making the public familiar with the value of the engineer and his work. In the past he felt that the resources of radio had been neglected for this purpose, and he thought that this matter should be referred to the Committee on Professional Interests. Mr. Newell undertook to bring this matter to the attention of that committee.

There being no further business, on the *motion* of Mr. Crealock, *seconded* by Professor McKiel, the meeting *adjourned* at six thirty p.m.

*The membership of these committees will be found on page 585 of the July issue of the Journal.

# The Next Fifty Years

*By the late Harrison P. Eddy, Hon. M.E.I.C.**
*Past-President, The American Society of Civil Engineers.*

**This address was prepared by Mr. Eddy for delivery in Montreal, June 16th, 1937, during the Semicentennial Celebrations of The Institute. Owing to his sudden and lamented death just after his arrival in Montreal, the address was sympathetically presented by F. S. B. Heward, A.M.E.I.C. It is published here by the kind permission of Mr. Eddy's family, and is memorable as the last message of an eminent and well beloved American engineer of international renown.**

To present observers the past fifty years appear to constitute a short period in comparison with the fifty years to come. With respect to past and future, the several professions differ materially in their objectives. The clergyman ministers to present spiritual needs; the doctor treats the current illness of his patient; the lawyer deals essentially with the present as based upon the past. He interprets laws which have been passed, not concerning himself with enactments of the future.

The engineer, on the other hand, deals essentially with the future. As the surveyor determines his forward course by first taking an observation on an established point in the rear, so the engineer utilizes the firm foundation of past experience and accumulated knowledge for the basis of his studies for the future. His bridges, his water works, his main highways, his ships, his communication systems, his machines, all are planned not for the past, not alone for the present, but for the future, often for a generation or more in advance.

Engineering as a profession has been said to date from about the seventeenth century, but during the past fifty years it has developed to such an extent that we are now living in an "engineering age." Fifty years ago we depended upon man and beast power, whereas today we depend largely upon mechanical means.

In the fifty year period before us there will be an accelerated advance in the accomplishments of engineering which, broadly speaking, is the application of science. New discoveries in science and their use by means of new inventions, will follow one another with ever-increasing rapidity. Often one discovery will reveal a score or more of new opportunities which speedily will be developed and made useful to man.

This acceleration in the speed of engineering advancement will be due in part to the increase in the number of workers in this field, made available through the competition of engineering colleges to gain students, and especially the growing conviction among parents, whether well-founded or not, that an engineering education carries with it an improved economic and social status. The public has become "engineering-minded."

No one can foretell with accuracy what specific results will ensue from this intensified development along engineering lines; but a few accomplishments are clearly evident:

Space, already so greatly reduced, will, practically speaking, be well nigh eliminated by the conquest of the air.

Mass-production will be extended to far more industries.

Agriculture will yield more and more to combination-control and mechanization. With the aid of new methods of processing and the discovery of synthetic foods, the necessary agricultural products for a unit of population, will be provided with a fraction of the labour and land now used.

Automatic control of production and operation will further greatly reduce the need for manual control.

New scientific discoveries, new sources of power and the development of new processes and inventions, will make necessities and many luxuries more generally available.

Such changes will inevitably shorten the work-time required to satisfy the demands of the public. In Canada and the States it has been reduced one-third during the last fifty years. Is it not probable that an equal reduction will result in the next fifty years? If so, the required work-time will become only one-half what it is at present. Probably twenty hours a week is a conservative estimate.

Whatever this reduction may be, it will result largely from the activities of the engineer. Credit for lightening the human burden, however, will be accompanied by liability for any unfortunate results which may ensue and the public will look to the engineer to provide the means to avoid them.

One of the greatest problems which will be created by such changes and which even now is urgently demanding attention is—

What shall we do with our released time and energy?

Some of the ill effects of a surplus of spare time already have become evident. Among a substantial number of persons there has apparently developed a lack of desire to work for the purpose of bettering their condition. To illustrate, it has recently been found so easy to do a minimum of work for a modicum of compensation, under the guise of relief, that the incentive to produce more for a greater reward has become atrophied. This tends toward a falling, not a rising standard of living.

We are wont to believe that our modern civilization has produced a higher standard of living. Unless this great problem of the application of leisure time is judiciously solved, the undirected forces of human nature may reduce the present standard of living and wreck our civilization.

"For Satan finds some mischief still
For idle hands to do"

will be as true as when stated by Isaac Watts.

The most obvious and popular solution of the problem seems to be the development of recreation, and in the next fifty years games, sports, hunting, fishing, travel and a long list of recreational pursuits will be brought within easy reach of more and more of the people. In providing such means the engineer will take a prominent part. New machines and equipment will be invented and used partly or exclusively for recreation; greater sums will be spent, for the most part under the technical direction of the engineer, on the development of highways, playgrounds, parks, and other recreational facilities. While this movement is valuable, is it to be the sole solution of the problem during the next fifty years? Can recreation take the place of work in providing training and discipline?

It has been said that

"Obedience to law is liberty."

Will the making available of so large a proportion of time for play result in producing a lack of respect for and obedience to law; will it diminish initiative and ambition? There certainly is grave doubt whether the solution can be found in recreation alone.

*Of Metcalf and Eddy, Consulting Engineers, Boston, Mass.

Another promising solution lies in the field of education. To quote Mr. H. G. Wells (*A Year of Prophesying—1925*):

"In the last two centuries . . . there has been much more than a tenfold increase in speed and a corresponding increase in security, versatility and comfort. Our mechanical power and mechanical productivity have increased in far greater proportion. There has been an educational advance also, but it has not kept pace with this . . . The education of a fully educated man is not conspicuously better than it was two hundred years ago . . . We believe that we are now in the dawn of a phase of educational thrust corresponding to the mechanical thrust of a century ago."

In harmony with Mr. Wells' prophecy I foresee a longer period of education for youth, extending perhaps to the completion of a junior college course, say at the age of twenty. This will provide a general education including opportunity for trade and vocational training, but it should not be continued too long, because youth is anxious to begin his life work; he is "champing at the bit"; his zest and ambition must not be permitted to wane.

In addition to this general education, post-scholastic study will become much more common and will provide both for entertainment and for the development of handicraft, science, the arts and literature. It will continue through adult life. There will ensue a return of the craftsman, who will work for the pleasure of working and to produce useful and ornamental things in the making of which he will take a just pride. The pursuits of art and literature are appropriate home avocations. Study and research in the home are not impracticable, and for the more involved work laboratories open to the public could be provided, where voluntary research could be carried out with adequate equipment and technical guidance.

The professional engineer of the future will be more highly educated than in the past. His four-year college training will be devoted to the fundamental sciences with generous allowances for the liberal arts and humanities. His professional study will follow in what we now call "post graduate" years. He will then have a service period of several years before he will formally enter the profession. Only by such modifications of the present prevailing college training can the engineer of the next fifty years be adequately equipped, or can he attain to the plane of responsibility which will be open to him if he is qualified to occupy it.

Providing for the future, as his work necessitates, recognizing and applying the discoveries in science and appreciating that there is a vast realm of the unknown yet to be explored, from which new truths are still to be learned, the engineer must be progressive and at the same time sound; he must distinguish fallacies from truths. If he takes advantages of his opportunities during the next fifty years, the engineer will exert a greater influence upon the progress of civilization and the well-being of mankind.

The scope of our engineering societies must be broadened. They must maintain a high technical standard through interchange of the results of experience and research, as the Institute has so well done in the past, but they must also devote more time and energy to the study of economic, social and governmental problems, both national and international. Only by applying the facts, laws and lessons of science to the development and control of human nature, can our engineering societies maintain their position of leadership.

# Contributors to Social Progress

*James H. Herron,*
*President, The American Society of Mechanical Engineers*

**An address delivered in Montreal, on June 15th, 1937, during the Semicentennial Celebrations of The Institute.**

In the early days of the automobile, when its approach was heralded by much clatter and clang, and its passage left lingering memories in visible and odorous vapours, a gentleman observed a mixed group of children at play. By a stretch of his imagination he perceived they were dramatizing the new and curious type of horseless vehicle. As only children can do, a rather compact group was putting into action the chief appealing features of noise, structure and motion as best they could represent it. Trailing this group at some distance a lone little coloured girl came running after, but never gaining distance on the main group.

The gentleman thought here is a case of social distinction and class ostracism. Accordingly, he accosted the little girl and asked: "What is the matter; won't the other children let you play with them?" She replied, "Oh! I am playing automobile with them, too." "Well, what part do you represent?" "Oh, I am just the gasoline smell."

Social progress has many activities; some accelerating, some retarding. Some of them could be eliminated and their absence would not be felt. Others could be converted from impeding influences to stimulating adjuncts. And still others are characteristically essential to any advancement that may be made. It may be well to turn our eyes aside from the purely professional aspects of Engineering to let them wander over the picture of social advancement and determine what manner of adaptation engineering may have in the progress toward the ultimate goal. Is it contributory to this progress in a direct and essential way; or is it an outgrowth of what has transpired, as a necessary evil? Is it an integral part of the social mechanism or is it the gasoline smell?

It may seem trite or academic to cite in concise terms what in the minds of all seems to have a vague general meaning. "Society" and its derived terms are so common in the vocabulary of every one that it would seem a superfluous effort and a waste of time, if not also a presumption upon the intelligence of this assembly, to define it. Yet we must understand that what we mean is the intercourse of men, their actions and reactions toward each other, in communities.

Regarded in this light it is quite apparent that it has no fixed status but is ever in a constantly changing flux from what it was to what it will be in the future, environed and influenced by new relations as they develop. The influences that determine the social status at any given time are grouped under several headings listed as factors of social relations. Time will not be taken to discuss them specifically. To merely mention them must suffice. They are social customs peculiar to a community, economics, civil relationships, ethics and religion. It need not be pointed out that these are inter-active and each is a factor in determining the direction development shall take in any of the others. What the ultimate end of social progress may be no one may predict in any certain manner; but all agree that it is on its way toward an ever advancing goal, probably as inaccessible as the rainbow.

To view the past history of humanity there has been at least an apparent betterment for the populace as a whole and an expansion of that betterment to affect greater numbers. The shadows of oppression, restricted means of living and the narrow limits of personal pleasure and enjoyment have been dispelled by the greater offerings of freedom, broader living, and more time and more extension of choice of recreational delights. Progress is admitted. If engineering has had a substantial part in its promotion, it has been in the field of economics.

Engineering developments have set up a new economic structure; and the greatest concern of the present day is that of harmonizing and balancing the forces arising from the changed situation so that employment, production and consumption may keep pace with each other. Community customs have ceased to be sharply differentiated. Rural life has been given the advantages of urban culture. Country and city are now meeting on a fairly equalized plane of social interest and behaviour.

Civic organization has been compelled to adjust its operations to fit the onward press of mechanical advancement. New laws must be enacted, old laws must be revamped to fit the present needs. Greater responsibilities are imposed upon the government and new means and sources of taxation must be sought in order to meet the added burden of expense.

Ethical and religious customs are affected perhaps less by the forward sweep of the material forces, but none the less certainly because of smaller degree. Yet it is to be noted, that creeds are breaking down their walls of intolerance. It is apparent that dispersion of education and culture through the facilities offered by design and invention is exercising a leveling influence in both moral and religious intercourse.

Then how very apparent it is that engineering is not the befouling exhaust from the dynamic forces driving the social organization to its destined goal. Rather it is the very engine itself; the central sun of a system energized by its radiated power. The profession is recruited from all ranks. The humble son of poverty and adversity may aspire to contribute something to what has been already done. He may gain a place in illustrious renown with Lord Kelvin or Sir Robert Hadfield. The Dominion has furnished its share of men eminent in the profession and distinguished for their intellectual and humanistic efforts.

These men have made available the natural resources. Where water has offered a source of power, plants and machinery to utilize the energy have been devised. Uses have been sought out resulting in new enterprises. Means to carry this energy successfully for long distance have been discovered. Where minerals have been stored in natural deposits, they have been made available, by airplane, by steam line, by motor truck. The vast lumber resources and the grain of western provinces have both found an outlet to the world's markets. If waterways are needed a Welland canal shows what can be done. If open water is blocked by ice to interfere with navigation in winter, the engineer finds a way to break the icy grip and speed the vessel on its way. If the natural beauty of rugged regions, the piscatorial sport of inland waters, the restful haunts of sylvan scenes call to the touring vacationist, the roads have been prepared and sustenance made accessible.

The world is narrowed, time abbreviated, and all the people made more intimately connected. If a king takes leave of his loving and beloved subjects, his voice is carried to their ears in every part of the vast empire. If a king be crowned, the coronation ceremony is pictured in the public prints almost before the tumult and the shouting dies. To the vast multitude of loyal souls who shout "Long live the King," the new-crowned king addresses his thoughts and bespeaks the patience, loyalty and support every true leader of a people desires to have.

Truly a small world, an intimate world, and let us hope a sincerely sympathetic world!

On this semicentennial anniversary commemorating the organization of The Engineering Institute, it is significantly fitting and wholly desirable that we take cognizance of those worthy fellows who made the pioneering effort in co-operative action. Some have rested from their labours, but their good deeds live after them. Some of that charter group may still enjoy seeing the fruits ripening on the tree springing from the seed they planted fifty years ago. If such there be, may we wish them peace and tranquillity as their declining sun sinks in the west. As a proper tribute to their prowess and their achievement it is worthy that each member of the profession shall resolve that the standards set and established up to this time shall never be lowered either in the quality of the service or in the ethics of the practice.

If there is any outstanding idea to which the attention should be directed, it is one to which allusion was made earlier in this discourse. Mere mention was made that ethics as a social factor had shown less progress than most of the other factors. Mention was also made of the economic problem of adjusting labour, production and consumption relations. Here the ethical phase seems to carry in part the solution of what is a very perplexing situation.

There are social ills and misfortunes which progress has not eradicated nor in any great measure corrected. They are inherent in individual differences yet based on a rather universal human trait of acquisitiveness and self seeking. The evidences are manifest in greed, antisocial attitude, dishonesty and oppression. Individual traits, within limits, are modifiable and controllable no less than our social relations and institutions. The social-economic order may be changed by wisely guided imaginative construction and clearheaded co-operative action.

Many of our leading thinkers, and some of the best in the engineering field, have focused attention on these outstanding deficiencies of our social life. They have applied the same keen analytical powers to secure the proper perspective. The problem has been outlined, but the key to its solution is still lacking. The difficulties to be overcome, the obstacles to be surmounted are no more invincible, no more baffling than nature has presented to the engineer who has won the victory.

While not strictly an engineering activity, it appears that the fraternity has the organization, the energy and capability as well as a mandatory duty to correct the conditions. Educate out the desire of capital and labour for the greatest material return in exchange for the least expenditure of effort. It must be made clear that life has an objective, not in acquiring the means of a livelihood, but in the realization of spiritual values. A start has been made to assure a maintenance, to free the mind of the threat of future dependency, to allow a greater relief from the tension of a strenuous struggle, and to afford an unrestricted leisure for spiritual comfort. Any effort to secure these ends is a step in removing selfishness from our social order, and in setting up the principle of universal brotherhood and injunction to "love thy neighbour as thyself."

# An Appreciation

*Edward P. Lupfer,*
*Vice-President, American Society of Civil Engineers.*

**A Toast presented on June 16th, 1937, at the Semicentennial Banquet of The Institute in Montreal, at which His Excellency the Governor General was the guest of honour.**

*Your Excellency, Mr. President, Ladies and Gentlemen:*

It is my high privilege to appear before this audience as the representative of the American Society of Civil Engineers—designated by that Society to present to you a toast—a toast which shall, simply yet clearly, express to you the profound regard and affection in which that Society holds the Engineering Institute of Canada.

The American Society of Civil Engineers takes pride in being privileged to share with you the celebration of your Semicentennial, and I bring to you its heartfelt felicitations for your continued prominence and influence in the engineering world, and its wish for your undiminished success in future years.

Yours has been a remarkable record over this past half century, a record of high achievement in a high calling—a record of achievement founded upon faith for the future of your splendid Dominion—a record of achievement founded upon character—character in your individuals, which makes for the character of your Dominion.

For the moment, go back before the founding of your Institute, fifty years ago. For centuries prior to its founding, your predecessors, under yours and other flags of other nations, had carried high the torch of their profession whilst changing a virgin country into a habitable place in which to live.

These predecessors of yours, enriched with the best blood and brain the world could procure, who, prior to the formation of your Institute, had for generations been building from coast to coast, and into the far reaches of the North, shared few of the many appliances of modern living which you enjoy, but their dominant characteristic was their faith in the future of their land.

With St. Paul they believed, "that faith is the substance of things hoped for, the evidence of things not seen," and so, "they subdued kingdoms and wrought righteousness" in this fair land and out of their efforts came a breed of men who carried on—a breed of men who have character, who have the will to endure and to achieve. These men constitute the membership of your Institute, and upon the great cardinal virtues which their forbears firmly embedded in them—rests its integrity and its future.

And we who live across the invisible border *from you*, are proud *of you* and of your achievements. Unafraid and unashamed, we take this occasion to tell you so. For after all, we of these two countries are much alike, very near akin to each other, each sharing with the other its like problems, and neither departing from the high ideals which each has firmly established.

Such an occasion as this comes rarely. On this occasion our Society has a deep concern and interest in your Institute. The members of your Institute and of our Society work side by side, exchange ideas—face the same identical problems—face the future with faith—with faith in the integrity of each other.

Shortly before his retirement as Prime Minister of Great Britain, Stanley Baldwin spoke in Albert Hall on May 19th to 8,000 young men and women, gathered from every far flung colony and dominion of your great empire. It was in effect, Mr. Baldwin's farewell address, and was, in my opinion, one of the ranking speeches of the century. In it, in part, he stated that "Europe today is neither at war, nor at peace, but stands at armed attention."

We Americans, you as citizens of a great Dominion, a dominant segment of a matchless empire, we, as citizens of the States, do not now, and never shall understand that condition. *Our* countries are organized *for*, and dedicated *to*, peace.

This invisible unarmed border line between the Dominion and the States, is melted into an indistinguishable haze by the spiritual quality of mutual respect and affection—which binds us each to the other, and which, stands unequalled in world's history.

This understanding between us may have become too much, far too much of a commonplace to us—perhaps we both err in not being more articulate to the world, regarding this great heritage which we enjoy and take so casually for granted. In reality, it is our duty to stress to the world our gratitude to each other for the ties which unite us.

In the autumn of 1927, I had, as my guest in Buffalo, that rare character, Dr. Arthur S. Pringle, clergyman and scholar of England. Dr. Pringle was concluding his first visit to the United States, and was homeward bound from St. Louis where he had been a prominent speaker at the Congress on World Peace.

Dr. Pringle was vitally interested in the Peace Bridge which had been opened between our two countries but a few months before. Before leaving the city he wrote me as follows: "Here, in your own city, you have a noble and an enduring symbol of how peace can best win and consolidate her victories. The Peace Bridge—so recently opened by high officials of the United States, of England and of Canada—has for its terminal at one end, the site of a disused fort, and on the other the place where battle was once waged—a parable in steel and concrete, so to speak, of how the scenes and resources of war can be conquered and absorbed in the cause of humanity and progress, and should not such a monument be an abiding incentive to your country and mine to build between us a bridge of understanding and comradeship which must go far to insure the Peace of the World!"

Between us then, we possess a common touch of such priceless value that we dare not and must not withhold it from the world. Of this bond, we are both rightly proud—this bond, between the peoples of these two great democracies, that for one hundred and twenty years has never been broken.

And we two peoples, glorying in our freedom, our equality, our priceless independence stand closely united. Living as we do in perfect harmony, perhaps it is not too much to hope that the world at large *may* follow our example and gain our priceless peace of mind. To this end both your Institute and our Society would gladly pledge themselves.

And so, from across the border, we admire, and applaud your faith in yourselves—your dignity, your farsightedness, we admire your unafraidness—your independence—your formal simplicity—your solidarity. Feeling as we do about you, a feeling engendered and tested over many decades of neighbourliness, we look with confidence to walking beside you down the coming years, refreshed and strengthened and encouraged by your presence.

Mr. President—with great sincerity and pleasure, on behalf of the American Society of Civil Engineers, I now propose a toast to the Engineering Institute of Canada. God grant—in the years that lie before us, this sacred covenant which so closely binds these two great Societies, as well as these two great countries, may never be disturbed.

## Recent Graduates in Engineering

Congratulations are in order to the following Associate Member, Juniors and Students of The Institute who have recently completed their course at the various universities:—

### Nova Scotia Technical College

#### Prize Award

Young, Angus Francis, Sydney, N.S.—B.E. (Mech.); Association of Professional Engineers' Prize.

#### Degree of Bachelor of Engineering

Curry, Herbert Nicholas, Windsor, N.S.—B.E. (Mining).
Thompson, James William Joseph, Halifax, N.S.—B.E. (Ci.).

### The University of New Brunswick

#### Medal Award

Ross, Donald, Saint John, N.B.—B.Sc. (Ci.); The Ketchum Silver Medal for the highest standing in Civil Engineering.

#### Degree of Bachelor of Science

Baird, Malcolm Francis, Fredericton, N.B.—B.Sc. (Elec.).
Boone, Harold Percival, Fredericton, N.B.—B.Sc. (Elec.).
Dibblee, Frederick Allan, Woodstock, N.B.—B.Sc. (Elec.).
McMillan, Thomas Stewart, Jacquet River, N.B.—B.Sc. (Ci.).
Olts, George Lounsbury, Fredericton, N.B.—B.Sc. (Ci.).
Peacock, Robert Frederick, St. John, N.B.—B.Sc. (Elec.).
Ralph, John Arthur, Quebec, Que.—B.Sc. (Elec.).
Rawland, Arthur Gordon, Quebec, Que.—B.Sc. (Ci.).
Scott, James Munro, Quebec, Que.—B.Sc. (Ci.).
Springford, William Robertson Hearne, Fredericton, N.B.—B.Sc. (Elec.).
Wilkinson, William Cameron, Campbellton, N.B.—B.Sc. (Elec.).
Wilson, Murray Edgar, Moncton, N.B.—B.Sc. (Elec.).

### McGill University

#### Honours, Medals and Prizes

Bourne, James Douglas, Westmount, Que.—B.Eng. (Elec.); Honours in Electrical Engineering.
Dean, William Warren Hope, Alexandria, Ont.—B.Eng. (Elec.); Honours in Electrical Engineering; Montreal Light, Heat and Power Consolidated Prize.
Duranceau, Charles Arthur, Montreal, Que.—B.Eng. (Ci.); Honours in Civil Engineering; British Association Medal; Undergraduate Society's Third Prize for Summer Essay.
Pengally, Charles Desmond, Mandeville, Jamaica, B.W.I.—B.Eng. (Mech.); Honours in Mechanical Engineering; British Association Medal.
Seifert, Harold Lorne Bain, Quebec, Que.—B.Eng. (Chem.); Honours in Chemical Engineering.
Simpson, John Hamilton, Montreal, Que.—B.Eng. (Elec.); Honours in Electrical Engineering; British Association Medal; Montreal Light, Heat and Power Consolidated First Prize.
Taylor, Dudley Robert, Montreal, Que.—B.Eng. (Elec.); Undergraduate Society's Second Prize for Summer Essay.

#### Degree of Doctor of Philosophy

Swartz, Joseph Norman, Fort William, Ont.—B.Eng. (McGill); Ph.D., (Chem.).

#### Degree of Master of Science

Sproule, William Kelvin, Westmount, Que.—B.Eng. (McGill); M.Sc. (Met.).

#### Degree of Bachelor of Engineering

Baker, William Gordon, Outremont, Que.—B.Eng. (Chem.).
Block, Jacob Benjamin, Montreal, Que.—B.Eng. (Chem.).
Budden, John Hastings, Larkhill, Wilts, England.—B.Eng. (Elec.).
Candlish, Fairlie, Montreal, Que.—B.Eng. (Mech.).
Collingwood, John Cuthbert, St. John's, Nfld.—B.Eng. (Elec.).
Davis, Eliot Robertson, Winnipeg, Man.—B.Eng. (Mech.).
Dick, William Arthur, Quebec, Que.—B.Eng. (Mech.).
Drake, Thomas Stuart, St. Catharines, Ont.—B.Eng. (Mech.).
Duckett, William Anderson, Montreal South, Que.—B.Eng. (Elec.).
Exelrod, Bert, Montreal, Que.—B.Eng. (Ci.).
Horwood, William Osmund, Montreal, Que.—B.Eng. (Mech.).
Jacobs, David Sinclair, Montreal West, Que.—B.Eng. (Ci.).
Jones, David Carlton, Vulcan, Alta.—B.Eng. (Mech.).
Killam, Frank Richard, Vancouver, B.C.—B.Eng. (Mech.).
King, Donald, Montreal, Que.—B.Eng. (Elec.).
Kingsland, Edward Notman, Westmount, Que.—B.Eng. (Mech.).
Kirkpatrick, Robert Evans, Montreal West, Que.—B.Eng. (Mech.).
Lacombe, Jean Louis, Sherbrooke, Que.—B.Eng. (Ci.).
LeBel, Harry W. S., Namur, Que.—B.Eng. (Mech.).
Lochhead, John Starley, Montreal West, Que.—B.Eng. (Ci.).
Loiselle, Harold John, Outremont, Que.—B.Eng. (Chem.).
Lyons, Joseph Harvey Kent, Winnipeg, Man.—B.Eng. (Mech.).
MacGibbon, James Alexander, Brownsburg, Que.—B.Eng. (Mech.).
McLean, Murray Douglas, Montreal, Que.—B.Eng. (Elec.).
MacLeod, Gordon Ross, Montreal, Que.—B.Eng. (Mech.).
Macnutt, Ernest Gerrard, Westmount, Que.—B.Eng. (Mech.).
Maguire, James Cornelius, Outremont, Que.—B.Eng. (Chem.).
Mahoux, Raymond Jean, Montreal, Que.—B.Eng. (Mech.).
Martin, Henri Milton, Edmonton, Alta.—B.Eng. (Chem.).
Moseley, Shirley Charles Tilton, Lunenburg, N.S.—B.Eng. (Mech.).
Nicholson, John Haines, St. Lambert, Que.—B.Eng. (Chem.).
Nowlan, Brete Cassius, Jr., Montreal, Que.—B.Eng. (Elec.).
Parker, Edmund Norval, Winnipeg, Man.—B.Eng. (Mech.).
Payan, Charles Frederick, St. Hyacinthe, Que.—B.Eng. (Chem.).
Pinder, Harold Clay, LaPorte, Sask.—B.Eng. (Mech.).
Scriver, Bruce MacKenzie, Outremont, Que.—B.Eng. (Chem.).
Senicie, Michael, Ladywood, Man.—B.Eng. (Mi.).
Shector, Lindley, Outremont, Que.—B.Eng. (Ci.).
Smith, Allan Garfield, Outremont, Que.—B.Eng. (Elec.).
Sparks, Roderick Fraser, Ottawa, Ont.—B.Eng. (Mech.).
Thomson, John Alexander, Carlisle, England—B.Eng. (Elec.).
Wesley, William Grant, Outremont, Que.—B.Eng. (Elec.).

### Ecole Polytechnique

#### Liste des Diplômes Décernés aux Elèves de la 61e Promotion 1936-37

Cousineau, Yvon, Montréal, Qué.—B.A.Sc. (Ci.); Médaille d'Argent de l'Association des Anciens Elèves de l'Ecole Polytechnique; Prix Paul d'Aragon pour succès en Mines.
DeGuise, Yvon, Verdun, Qué.—B.A.Sc. (Ci.), avec "Grande Distinction"; Médaille de Bronze de l'Association des Anciens Elèves de l'Ecole Polytechnique.
Des Ormeaux, Dollard, Montréal, Qué.—B.A.Sc. (Ci.), avec "Grande Distinction."
Leblanc, Raymond F., Montréal, Qué.—B.A.Sc. (Ci.); Prix de la 50e Promotion de l'Ecole Polytechnique offert à l'élève qui a soumis la meilleure thèse industrielle de fin d'année.
Lecavalier, Jean Paul, Montréal, Qué.—B.A.Sc. (Ci.), avec "Très Grande Distinction; Médaille d'Argent du Lieutenant Gouverneur de la Province de Québec; Médaille d'Or de l'Association des Anciens Elèves de l'Ecole Polytechnique; Prix d'Architecture Ernest Cormier.
Pouliot, Paul Louis, Montréal, Qué.—B.A.Sc. (Ci.), avec "Distinction."
Rose, Paul Emile, Montréal, Qué.—B.A.Sc. (Ci.); Médailles de Bronze de l'Association des Anciens Elèves de l'Ecole Polytechnique.
Saintonge, Rosaire, Montréal, Qué.—B.A.Sc. (Ci.), avec "Distinction."
Simard, J. Marcel, Montréal, Qué.—B.A.Sc. (Ci.), avec "Distinction."

#### Ingénieurs Civils

Bolduc, Armand, Montréal, Qué.—B.A.Sc. (Ci.).
Buteau, Lucien, Montréal, Qué.—B.A.Sc. (Ci.).
Desmarais, Jean René, Montréal, Qué.—B.A.Sc. (Ci.).
Dufour, Gaston, Outremont, Qué.—B.A.Sc. (Ci.).
Frigon, Rosario, Shawinigan Falls, Qué.—B.A.Sc. (Ci.).
Lemieux, Roland A., Montréal, Qué.—B.A.Sc. (Ci.).
Mailhot, Gaston, Montréal, Qué.—B.A.Sc. (Ci.).
Richer, Baxter, Montréal, Qué.—B.A.Sc. (Ci.).
Roy, Louis Philippe, Montréal, Qué.—B.A.Sc. (Ci.).
Scheen, Marcel, Montréal, Qué.—B.A.Sc. (Ci.).

### Queen's University

#### Honours, Medals and Prizes

Carson, Robert John, Kingston, Ont.—B.Sc. (Ci.); Honours in Civil Engineering.
Elmsley, Clarence Mathieu Remy, Windsor, Ont.—B.Sc. (Mech.); Honours in Mechanical Engineering.
Hyde, Arthur Edwin, Hamilton, Ont.—B.Sc. (Met.); Honours in Metallurgical Engineering; Departmental Medal.
Scobie, Alexander Gordon, Hamilton, Ont.—B.Sc. (Chem.); Honours in Chemical Engineering; Departmental Medal; The E. T. Sterne Prize in Chemical Engineering.
Swingler, Russell Henry, Port Arthur, Ont.—B.Sc. (Mech.); Honours in Mechanical Engineering; Departmental Medal; L. M. Arkley Prize.

#### Degree of Bachelor of Science

Ahearn, William Jefferson, Ottawa, Ont.—B.Sc. (Elec.).
Andre, Kenneth Bailey, Kingston, Ont.—B.Sc. (Ci.).
Ansley, Frederick Charles, Toronto, Ont.—B.Sc. (Ci.).
Briceland, Emmett Vincent, Kingston, Ont.—B.Sc. (Mech.).
Crothers, Donald Coverdale, Kingston, Ont.—B.Sc. (Mech.).
Giles, J. Oscar, Sarnia, Ont.—B.Sc. (Mech.).
Gordon, John Edward, Dundas, Ont.—B.Sc. (Mech.).

Hertel, Alfred Barnard Frederick, London, Ont.—B.Sc. (Ci.).
Kennedy, Harold E., Toronto, Ont.—B.Sc. (Mech.).
Kent, Allan Douglas, Kingston, Ont.—B.Sc. (Mech.).
Marshall, Welsford Allen, Ottawa, Ont.—B.Sc. (Ci.).
Molland, Frederick William, Thorndale, Ont.—B.Sc. (Mech.).
Robinson, William Morecroft, Dundas, Ont.—B.Sc. (Mi.).
Sanders, George Ostrom, Cornwall, Ont.—B.Sc. (Mech.).

## Royal Military College

### Prize Award

Drury, C. H., Montreal, Que.—Graduate. Second-Class General Proficiency Prize.

### Graduates

Ross, J. H., Kingston, Ont.
Savard, J. G., Kingston, Ont.

## University of Toronto

### Degree of Doctor of Philosophy

Heatley, Albert Harold, Toronto, Ont.—B.A.Sc., M.A., Ph.D.

### Degree of Master of Applied Science

Corbett, Bruce Sherwood, Edmonton, Alta.—B.Sc. (Alberta). M.A.Sc.
Dembitzky, Thomas Morris, Toronto, Ont.—B.A.Sc., M.A.Sc.
McRae, Robert Bruce, Edmonton, Alta.—B.Sc. (Alberta). M.A.Sc.

### Degree of Civil Engineer

Sagar, William Lister, Toronto, Ont.—B.A.Sc., C.E.

### Degree of Bachelor of Applied Science

Bodwell, Geoffrey Lionel, Toronto, Ont.—B.A.Sc. (Ci.).
Christian, John Despard, Toronto, Ont.—B.A.Sc. (Mining).

## University of Manitoba

### Medal Award

Moule, Gerald W., Winnipeg, Man.—B.Sc. (Elec.); University Gold Medal.

### Degree of Bachelor of Science

Arnason, Einar, Winnipeg, Man.—B.Sc. (Elec.).
Henselwood, Edward Wilton, W. Kildonan, Man.—B.Sc. (Elec.).
McIntosh, William Gardner, Winnipeg, Man. B.Sc. (Elec.).
Miller, John Jackson, Winnipeg, Man.—B.Sc. (Elec.).
Robinson, Arthur Harold, Winnipeg, Man.—B.Sc. (Ci.).
Scarlett, Barnes Kossuth, Winnipeg, Man.—B.Sc. (Elec.).
White, William Barr, Winnipeg, Man.—B.Sc. (Ci.).
Wilson, Bertram Henry John, Winnipeg, Man.—B.Sc. (Ci.).

## University of Alberta

### Honours and Prize Awards

Edwards, Milton Chalbers, Edmonton, Alta.—B.Sc. (Elec.); Honours in Electrical Engineering.
Hindle, Walter, Edmonton, Alta.—B.Sc. (Elec.); Honours in Electrical Engineering.
Martin, Tom Elbert, Edmonton, Alta.—B.Sc. (Chem.); The Association of Professional Engineers of Alberta Prize.
Poole, John Edward, Edmonton, Alta.—B.Sc. (Ci.); Honours in Civil Engineering; The Association of Professional Engineers' of Alberta Prize.
Thompson, Arthur McCall, Edmonton, Alta.—B.Sc. (Elec.); Honours in Electrical Engineering; The Association of Professional Engineers' of Alberta Prize.
Waters, Donald Samuel Brooks, Calgary, Alta.—B.Sc. (Ci.); Honours in Civil Engineering.

### Degree of Bachelor of Science

Algot, Clarence Aldo, Derwent, Alta.—B.Sc. (Elec.).
Bogart, Evan Winston, Edmonton, Alta.—B.Sc. (Chem.).
Burke, John Abel, Lethbridge, Alta.—B.Sc. (Ci.).
Chambers, Robert, Edmonton, Alta.—B.Sc. (Elec.).
Connell, Gordon Allen, Edmonton, Alta.—B.Sc. (Chem.).
Elford, Wesley Fred, Foremont, Alta.—B.Sc. (Elec.).
Forsythe, Marshall Anthony, Clover Bar, Alta.—B.Sc. (Elec.).
Hurst, Charles Kenneth, Calgary, Alta.—B.Sc. (Ci.).
Kirkland, William Dalton, Edmonton, Alta.—B.Sc. (Elec.).
Klodniski, Nicholas Albert, Edmonton, Alta.—B.Sc. (Elec.).
Oliver, James, Calgary, Alta.—B.Sc. (Ci.).
Redmond, William Lawson, Edmonton, Alta.—B.Sc. (Mi.).
Stafford, James Walter, Edmonton, Alta.—B.Sc. (Elec.).

## Elections and Transfers

At the meeting of Council held on July 16th, 1937, the following elections and transfers were effected:—

*Member*

SANNE, Einar Trygue, chief dftsman., Montreal Locomotive Works Ltd., Montreal, Que.

*Associate Members*

ASTELS, Fletcher, B.S. (E.E. and C.E.), (Tri-State College), 474 Cooper St., Ottawa, Ont.
ALLEN, Archie Menzo, constrn. engr., Alberta Government Telephones, Edmonton, Alta.
BUTLER, Ernest, (Inst. Technology, Manchester), chief designer, Wayagamack Divn., Consolidated Paper Corpn., Three Rivers, Que.
EVANS, Beverley Abbott, B.Sc., M.Sc., (Univ. of Sask.), senior asst. engr., Dept. of Public Works, Canada, Saskatoon, Sask.
HARLING, Frank Norman, B.Sc., (McGill Univ.), engr., Canadian Industries Ltd., Montreal, Que.
MOLLER, Holger Peter, E.E., (Royal Tech. Coll., Copenhagen), elec. supt., Lake St. John Power and Paper Co Ltd., Dolbeau, Que.
McRAE, Ian F., asst. works manager, Peterborough plant, Can. Gen. Elec. Co. Ltd., Peterborough, Ont.
ODELL, Russell Kenneth, (Royal Naval College), chief, development divn., Bureau of Economic Geology, Department of Mines, Ottawa, Ont.
ORLANDO, Edward Eugene, B.Sc., (N.S. Tech. Coll.), sales engr., Canadian Westinghouse Co. Ltd., Montreal, Que.
PARE, A Euclide, B.A.Sc., C.E., (Ecole Polytechnique, Montreal), asst. engr., hydraulic service, Dept. of Public Works, Quebec, Que.
ROLPH, Frank Bernard, (Grad., R.M.C.), B.Sc., (McGill Univ.), engr. i/c field constrn., John S. Metcalf Co. Ltd., Montreal, Que.
STALKER, Andrew Douglas, (Queen's Univ.), asst. city water works engr., Ottawa, Ont.
WANGEL, Reinhold, C.E., (Tech. Univ. of Finland), designer, heating dept., Warden King Ltd., Montreal, Que.

*Juniors*

COLPITTS, Cecil Ashton, B.Sc., (Univ. of Man.), transitman, C.P.R., Calgary, Alta.
HENSON, George Stanley Gordon, B.Sc., (Univ. of Man.), dftsman., Winnipeg Electric Co., Winnipeg, Man.
LEFRANCOIS, J. Germain, B.A.Sc., C.E., (Ecole Polytechnique, Montreal), sales engr., Canadian Fairbanks Morse Co. Ltd., Montreal, Que.
PETERSON, Alfred, B.Eng., (McGill Univ.), instrument engr., Abitibi Power and Paper Co., Iroquois Falls, Ont.
TAYLOR, Thomas Allistair Ian Clar, B.Sc., (Univ. of Alta.), plant engr., Saguenay Power Co. Ltd., Isle Maligne, Que.

*Transferred from the class of Associate Member to that of Member*

BUCHANAN, Colin Archibald, B.Sc., (McGill Univ.), chief engr., Donnacona Paper Co. Ltd., Portneuf, Que.
PEARSON, Vernon, (Brassey Institute), mech. supt., Govt. of Alberta, Edmonton, Alta.

*Transferred from the class of Junior to that of Associate Member*

CRATCHLEY, Reginald Henry, office engr., Penitentiaries Branch, Department of Justice, Ottawa, Ont.
de JONG, Sybren Henry, B.Sc., (Univ. of Man.), compiler, Topographic and Air Surveys Branch, Dept. of Mines and Resources, Ottawa, Ont.
HARDY, Robert McDonald, B.Sc., (Univ. of Man.), M.Sc., (McGill Univ.), lecturer in civil engrg., University of Alberta, Edmonton, Alta.
McCORMACK, Donald Neill, B.Sc. (E.E. and C.E.), (Univ. of N.B.), engr., Spruce Falls Power and Paper Co. Ltd., Kapuskasing, Ont.
NEIL, John Stuart, B.Sc., (Univ. of Alta.), test engr., Canadian Western Natural Gas, Light, Heat and Power Co. Ltd., Calgary, Alta.
WILLIAMS, Richard Louis, B.Sc., (McGill Univ.), designer and estimator, Dominion Bridge Co. Ltd., Lachine, Que.

*Transferred from the class of Student to that of Junior*

LILLEY, Ledford George, B.Sc., (Univ. of N.B.), dftsman. Dept. Public Works of Canada, Saint John, N.B.
MATHIESON, John Richard, B.Sc., (Univ. of Man.), designer-dftsman., C. D. Howe Co. Ltd., Port Arthur, Ont.
PASK, Arthur Henry, B.Sc., (Univ. of Man.), asst. plant engr. Eagle Pencil Co. Ltd., Drummondville, Que.

*Students Admitted*

ANSLEY, Fred C., B.Sc., (Queen's Univ.), 826 Argyle Road, Walkerville, Ont.
FAST, Morris, (Univ. of Sask.), 785 Hartland Ave., Outremont, Que.
LAVERGNE, Emile Denis, B.S. in C.E., (Univ. of Mich.), 57 Fifth St., Shawinigan Falls, Que.
LOWLES, George Albert, B.Eng., (McGill Univ.), chemist, Canadian Industries Ltd., Montreal, Que.
MYERS, Gordon Alexander, B.Eng., (N.S. Tech. Coll.), 134 Henry St., Halifax, N.S.
PRITCHARD, Geoffrey Rowland, B.Sc., (Univ. of Man.), 175 Oakdale Place, St. James, Man.
TOWLE, Harold Martin, (McGill Univ.), 302 Cote de Liesse Road, Mount Royal, Que.
WELDON, George Horace, B.Sc., (Univ. of Man.), 267 Woodlawn St., Winnipeg, Man.

# RECENT ADDITIONS TO THE LIBRARY

**Proceedings, Transactions, etc.**

Canadian Institute of Mining and Metallurgy: Transactions 1936.
The American Society of Mechanical Engineers: Transactions, July 1937, Vol. 59, No. 5, Sections 1 and 2.
Electric Supply Authority Engineers' Association: Transactions 1936, Vol. IX.

**Reports, etc.**

*Purdue University, Engineering Bulletin:* Vol. XXI, No. 1, Uncommon Oscillograms of Common Electrical Circuits, by G. V. Mueller; No. 2, Developments in Road Stabilization, by A. R. Brickler.
*University of Washington, Engineering Experiment Station:* Bulletin No. 93, Part I, Electric Heating of Residences, by Carl Edward Magnusson.
*The Institution of Mechanical Engineers:* Brief Subject and Author Index of Papers in the Proceedings from 1847-1936.
*The Ohio State University, Engineering Experiment Station:* Bulletin No. 95, Lead Frits and Fritted Glazes by J. H. Koenig.
*American Institute of Steel Construction:* Stress Distribution in Steel Rigid Frames, Progress Report Nos. 3, 4 and 5.
*Hydro-Electric Power Commission of Ontario:* 29th Annual Report 1936.
*Canada, Dept. of Mines and Resources, Bureau of Mines:* Annual Report of the Explosives Division 1936.
*Canada, Dept. of Mines and Resources, Geodetic Service:* Publications No. 57, Bench Marks in Ontario East of Toronto and North Bay; and No. 58, Bench Marks in Ontario West of Toronto and North Bay, by R. H. Montgomery.
*Canada, Dept. of Mines and Resources, Bureau of Mines:* Industrial Waters in Canada by Harald A. Leverin, Interim Report, No. 2, May 1937.
*Edison Electric Institute:* A-C Network Operation 1934-1935.
*National Research Council of Canada, Division of Research Information:* Heat Loss Through Windows by R. Ruedy.
*Leipziger Messamt:* Technical Reports 1936, by Prof. Loschge, Technical University, Munich.

**Technical Books, etc.**

Design of Welded Piping, (*Linde Air Products Company*) (*Presented by the Dominion Oxygen Co. Limited, Toronto.*)
Engineers and Empire Development, Presidential Address of Sir Alexander Gibb, G.B.E., C.B., F.R.S., to the Institution of Civil Engineers 1936. (*Presented by Sir Alexander Gibb,* M.E.I.C.)
How to Run a Lathe, 33rd Edition, 1937 (*South Bend Lathe Works*).
Some Data in Regard to Foundations in New Orleans and Vicinity (*Works Progress Administration of Louisiana.*)

# BOOK REVIEWS

## Storage Reservoirs

*By George Bransby Williams, Chapman and Hall Limited, London 1937 9 by 6 inches 25/- Cloth 300 pages.*

The severe droughts of recent years followed by the floods in England, America and elsewhere, have aroused general interest in the question of the regulation of the flow of rivers. An obvious way of controlling the flow of a river is by building storage reservoirs on its catchment. Of all the forms of engineering enterprise, none has affected the welfare of the human race more materially than the design and construction of storage reservoirs. They have been built all over the world for all sorts of purposes. In India they provide the irrigation water that preserves many millions of the inhabitants of that country from the dangers of ruin and starvation to which their ancestors have been exposed for ages. They hold the water supply of the largest cities, and, feed the hydroelectric power stations from which an increasing proportion of the world's electric energy is derived. Reservoir projects for flood control have been carried out, or proposed, in some parts of America, and are now contemplated on a much larger scale to prevent the recurrence of disasters such as that which recently overwhelmed the Ohio Valley. The construction of storage reservoirs has become popular, a national, even an imperial question and concerns not only engineers. Their part is to design and construct the reservoirs, but the public has to find the money, and now the latter are beginning to realise that money spent on protection against droughts and floods will probably prove an economic insurance.

A treatise on this subject by Mr. George Bransby Williams gives an up-to-date description of the principles on which these reservoirs should be designed. The book is largely technical, and written for practising engineers, but much of it, for example the portions dealing with rainfall phenomena in various parts of the world, methods of estimating the volumes of water likely to be discharged in floods, the types of dams built in Great Britain, America, India and elsewhere, and an illustrated itinerary of a journey round many of the reservoirs and dams of Great Britain, will appeal to many who possess little engineering knowledge.

The book contains eleven chapters in all some 300 pages. It is well illustrated with a large number of exceptionally clear diagrams and also photographs. Of particular interest to the designing engineer are the chapters on single-arch masonary and gravity dams; multiple arch, reinforced concrete, earth, hydraulic-fill and rock-fill dams. Chapters VIII, IX and X cover regulation of storage, methods of construction and the treatment of water supplies.

## Foundations in New Orleans and Vicinity

*Compiled by the Soil and Foundation Survey, a project of the Works Progress Administrations of Louisiana. (Published by the Works Progress Administration of Louisiana, New Orleans, Lo.) 1937. 13 x 16 inches. Cloth 277 pages.*

"Some data in Regard to Foundations in New Orleans and Vicinity." is the result of investigations carried out at the suggestion of the Louisiana Engineering Society and while setting an excellent example to many cities fulfills, in the case of New Orleans, a long felt need for a comprehensive collection of data on foundation conditions and building settlements.

Numerous instances of settlement due to the deep, soft ground in that region, promise to make the records just published of permanent value.

The volume contains four main chapters covering the history and geology of the region and including a map of New Orleans 35 x 38 inches which locates the test borings—referred to in Chapter II. These 239 test borings are described by means of stratigraphs many being carried to depths as great as 400 feet. Chapter III covers pile foundations and IV spread footings. A large amount of information is also included in the records of the foundation construction and settlement of nearly eighty buildings, stacks, seawalls and bridges.

It is not intended that the data contained in this publication should be used as an authority for the design of similar structures but as a reference of actual factual data to be used by engineers and architects in solving foundation problems of similar kinds.

## Refrigeration Engineering

*By H. J. Macintire. John Wiley and Sons, New York. (Renouf Publishing Company, Montreal) 1937. 9 x 6 inches. $4.50. Cloth 415 pages.*

The author is professor of refrigeration in the University of Illinois and his book is intended to present the subject of refrigeration engineering to senior engineering students.

The expanded field of refrigeration has been treated from fundamentals, assuming a knowledge of thermodynamics. The early chapters containing the theory and covering such subjects as thermodynamics, theoretical cycles of compression machines, refrigerants, flow of fluids and heat transfer, insulation, evaporation and liquefaction and finally the adsorption and its allied cycles. The liberal use of illustrative examples has made the mathematical material easy to follow.

Chapter III on refrigerants and properties of saturated and superheated vapours contains some useful tables.

The last decade has seen a remarkable advance in the refrigeration industry bringing a clearer conception of the mechanism of certain phases of heat transfer with the result as the author points out, that the design of condensers and evaporators has been radically changed and improved.

Chapters IX to XV include material on the following subjects:—compression and automatic refrigerating machines, household machines, the erection, operation and testing of machines, air conditioning, cold storage, ice manufacture and special applications.

The book is well illustrated with diagrams and a considerable number of references to the sources of information are provided in the form of footnotes.

## BULLETINS

*Elevating Graders.*—An 8-page bulletin issued by the Caterpillar Tractor Company, Peoria Illinois, gives particulars of their engine driven plough and carrier, with 48 and 42 inch carrier belt.

*Diesel Engines.*—Caterpillar Tractor Company, Peoria Illinois, have issued a 32 page booklet giving examples of the uses and the large number of industries operating these engines.

*Welding in Construction Work.*—The Lincoln Electric Co., Cleveland Ohio, have issued a 12 page pamphlet giving examples of the uses of welding in construction work. This includes considerable data and various examples are illustrated.

*General Electric Motors.*—A 4-page booklet has been received from the Canadian General Electric Co., Ltd., giving a few particulars of a number of their standard types of motors and starters.

*Couplings.*—Dominion Engineering Company have prepared a 12-page bulletin with details of Gearflex couplings.

*Tractors Road Machinery and Engines.*—A 32-page bulletin received from the Caterpillar Tractor Company, Peoria Illinois illustrates the many types of construction work on which this equipment may be utilized.

*Mine Pumps.*—This 6-page leaflet issued by the Worthington Pump and Machinery Corporation, Harrison, N. J. describes the wide range of pumping equipment manufactured by this company.

*Sewage Sludge Gas Engines.*—An 8-page bulletin issued by the Worthington Pump and Machinery Corpn., Harrison, N. J. describes the use of sewage sludge gas as a fuel for engines.

*Paper Stock Pumps.*—These are described in an 8-page booklet issued by the Worthington Pump and Machinery Corpn. They are of the centrifugal type and are capable of handling paper at all consistencies.

*Air Compressors.*—An 8-page bulletin received from the Worthington Pump and Machinery Corpn., illustrates their vertical single stage air compressor giving particulars of the construction.

## How to Run a Lathe

The 33rd edition of the well-known machinists' manual, "How to Run a Lathe," has recently been announced by its publisher, The South Bend Lathe Works, South Bend, Indiana. The new edition has 160 pages containing information about modern lathe practice accompanied with more than 300 illustrations.

Copies are priced at 25 cents each, and will be mailed post-paid anywhere in the world.

## Congress of Engineers

**Paris—September, 1937**

In connection with the International Exposition which is being held in Paris this year, a Congress of Engineers will be held from the 26th to the 29th September at which foreign engineers will be welcome. Applications for membership (accompanied by a remittance of 75 fr.) should be addressed to:

M. Ferrier,
9 rue Pasteur,
Levallois-Perret (Seine), France.

In addition to the technical sessions, members can take advantage of special rates on the French Railways and at the Exposition—an extensive programme of technical visits is also being arranged to power stations, laboratories and industrial establishments.

Further information can be obtained from the Secretary of the Organization Committee, 19 Rue Blanche, Paris (IX )

## President's Visits to Western Branches

G. H. Desbarats, Hon. M.E.I.C., President of the Engineering Institute of Canada is leaving Ottawa on August the fifth for a visit to the Western Branches of The Institute. The following is his itinerary according to present plans.

Sault Ste Marie, Ontario, August 6th to 8th.
Fort William, Ontario, August 9th.
Regina, Saskatchewan, August 10th to 12th.
Lethbridge, Alberta, August 14th.
Calgary, Alberta, August 15th to 16th.
Vancouver, August, 20th and 24th to 26th.
Victoria, August, 21st and 22nd.
Edmonton, Alberta, August 28th.
Winnipeg, Manitoba, August 29th to 31st.
Port Arthur, Ontario, September 1st.

## Joint Meeting of the Institute and The American Society of Civil Engineers Hotel Statler, Boston, Mass.

**Wednesday, Thursday and Friday, October 6th, 7th and 8th, 1937**

### Outline Programme

(*Subject to minor changes*)

Wednesday—October 6th

*Morning:*

Registration.

Joint Session of the American Society of Civil Engineers and The Engineering Institute of Canada.

*Chairman:* Frank A. Barbour, M.Am.Soc.C.E., M.E.I.C.

Addresses of welcome from the State and the City will be given by the Governor of Massachusetts and the Mayor of Boston.

Responses by Louis C. Hill, President, American Society of Civil Engineers and George J. Desbarats, President, The Engineering Institute of Canada.

Brief addresses will follow by Dr. James Bryant Conant, President of Harvard University, and Dr. Karl Taylor Compton, President of Massachusetts Institute of Technology.

An address on The Cultural and Technical Background of the "New Architecture" will be given by Walter Gropius, Professor of Architecture, Harvard University.

At luncheon the speaker will be Colonel Willard T. Chevalier, Past-Director of the American Society of Civil Engineers. Colonel Charles R. Gow, M.Am.Soc.C.E., presiding.

*Afternoon:*

The afternoon will be devoted to a joint meeting, conducted by The Engineering Institute of Canada, *Chairman:* Fred. Newell, Member of Council, The Engineering Institute of Canada. The following papers will be presented and discussed:

**"The Substructure of the New Highway Bridge over the Fraser River at New Westminster, British Columbia,"** by Major Wm. G. Swan, M.E.I.C., Consulting Engineer, Vancouver, P.C.

**"Recent Developments at the Port of Halifax,"** by E. H. James, M.E.I.C., Consulting Engineer, Montreal, Que.

**"The Conception and Design of the Outardes Hydro-Electric Project."** by H. G. Acres, M.E.I.C., Consulting Engineer, Niagara Falls, Ontario.

On Wednesday evening entertainment will be arranged for members and guests, including ladies.

Thursday, October 7th

*Morning and afternoon:*

Meetings of the following six divisions of the American Society of Civil Engineers will be held simultaneously in four rooms:—

(*a*) Soil Mechanics and Foundation Division.
(*b*) Sanitary Engineering Division and City Planning Division.
(*c*) Surveying and Mapping, Division and Waterways Division.
(*d*) Engineering-Economics Division.

Among the various topics to be dealt with the following may be named:

**"Applications of Soil Mechanics to the Design of Levees in the Lower Mississippi Valley."**
**"The Application of Soil Mechanics to Building Foundations."**
**"The Pollution of Boston Harbour."**
**"Land Registration in Massachusetts."**
**"Recent Developments in Marine Borer Studies."**
**"The Hazards of Uneconomic Public Works Construction."**
**"The Economic Advantages of Orderly Planning of Public Works."**

In the evening a dinner and dance will take place in the Imperial Ball Room. Edward L. Moreland, M.Am.Soc.C.E., presiding.

Friday, October 8th

The closing day of the meeting will be devoted to inspection trips, including visits to Harvard University, and the Massachusetts Institute of Technology, followed by an excursion to the North Shore, Nahant and Marblehead. All the parties will meet at the New Ocean House, Swampscott, for a New England Shore Dinner at one o'clock.

For those who wish to go further afield, transportation will be provided to the Cape Cod Canal, which is being enlarged, and to the Quabbin Dam of the Metropolitan District Water Supply Commission, which is under construction by the hydraulic fill method.

Special excursions are being arranged for ladies as follows:

Wednesday, October 6th

Visit to the Isabella Gardner Museum, Boston.

Thursday, October 7th

Trip to Concord and Lexington with luncheon at Wayside Inn, Sudbury, Mass.

# BRANCH NEWS

## Border Cities Branch

*J. F. Bridge, A.M.E.I.C., Secretary-Treasurer.*
*F. J. Ryder, Jr.E.I.C., Branch News Editor.*

The last meeting of the Border Cities Branch prior to the summer adjournment was held in the Prince Edward hotel, Friday evening May 28th, 1937.

E. T. Harbert, A.M.E.I.C., chief designer of the Compressor Department of the Canadian Ingersoll Rand Company, Sherbrooke, Que., presented the members with an illustrated paper on "The Design of Air Compressors."

The paper was confined to the features of design as they affect the user. The pressure ranges of modern machines are vacuum to atmospheric; atmospheric to 2 or 3 lb.; atmospheric to 80 lb. to 7,000 to 8,000 lb. These pressures may be obtained by one of the following classes of machines: blowers, reciprocal centrifugal, rotary and hydraulic compressors. In selecting a machine the following conditions should be considered:

1. Capacity required (cubic feet of free air per minute.)
2. Power consumption.
3. Operating Pressure (100 lb. per square inch standard.)
4. Losses occurring in pipe lines, fittings and valves.
5. Intermittent use calls for storage receiver.
6. If air at two different pressures is required it is usually more economical to have two installations as reducing valves are wasteful of power.

Power consumption is based on isothermal formula.

The losses occurring are: friction of machine, heating of air, through intake valves, friction in pipe lines and reducing valves.

Types of prime movers used are: electric motor (most common), steam engine, oil engine, most of these being of the constant speed type.

Compressor valves are the heart of the compressor and have seen many changes. The more familiar types are: the poppet valve, corliss leaf, plate and channel valves.

New compressors as compared with older types are smaller, more efficient, occupy less floor space. The use of long sweep elbows assists in reducing friction losses in the pipe line.

Where storage receivers are used the capacity of tank is usually the capacity of compressor for one minute.

A very hearty vote of thanks was moved by J. E. Porter, A.M.E.I.C., and extended to Mr. Harbert by C. F. Davison, A.M.E.I.C., the Branch chairman.

## London Branch

*D. S. Scrymgeour, A.M.E.I.C., Secretary-Treasurer.*
*Jno. R. Rostron, A.M.E.I.C., Branch News Editor.*

The regular monthly meeting was held on the 20th May, 1937, in the Council Chamber, County Buildings, London.

The speaker of the evening was S. W. Archibald, M.E.I.C., and his subject "Flood Control on Western Ontario Streams."

W. C. Miller, M.E.I.C., presided, in the unavoidable absence of the Branch chairman, A. O. Wolff, M.E.I.C.

Mr. Miller, when introducing the speaker, who is one of the Branch members, referred to the disastrous flood of the River Thames on the 26th and 27th April last and pointed out, that although Mr. Archibald's paper has been prepared some time previously to those dates, it was now most opportune in view of measures which are at present under consideration for preventing any recurrence of such a catastrophe.

### Flood Control on Western Ontario Streams

The evolution of drainage and flood control measures in England was traced from the early enactments of the reign of Henry VIII to the present time, dealing particularly with the report of a special committee of the House of Lords presented in 1877, the report of the Royal Commission appointed in 1927 and the subsequent Land Drainage Act of 1930. Briefly, the findings of the Royal Commission of 1927 were very similar to those of the House of Lords special committee and recommended drastic revision and repeal of existing drainage and control legislation. Outstanding conclusions of the Royal Commission were: firstly, that all upland owners contributing water in any way by artificial means, were responsible to some extent for the safe passage of the waters from their lands to the sea. Secondly, that the financial interest of any lands in any drainage and river control works should be determined by the "annual value" of such lands. Thirdly, that to arrive at a comprehensive and satisfactory system of control, arterial streams and drainage channels should be designated as "Catchment areas" and the full control of such streams and the works thereon should be vested in catchment area boards composed of representatives of all municipalities and authorities interested. The recommendations of the Royal Commission were largely acted upon by the passing of the Land Drainage Act, 1930. The catchment areas recommended by the Royal Commission were approved and provision made for establishing others. The following are definitions taken from Land Drainage Act, 1930: "Drainage," except in the phrase "any enactments relating to the drainage of land," includes defence against water, irrigation, warping and the supply of water"; "Drainage authority" means any drainage board constituted, or to be treated as having been constituted, under this Act, or any other body of persons having power to make or maintain works for the drainage of land"; "Land" includes water and any interests in land or water and any easement or right in, to, or over land or water"; "Main river" includes any structure or appliance for controlling or regulating the flow of water in or out of the channel, and situate therein or in any part of the banks thereof other than any such structure or appliance which is vested in or controlled by an internal drainage board"; "Watercourse" includes all rivers, streams, ditches, drains, cuts, culverts, dykes, sluices, sewers (other than sewers under the control of a local authority within the meaning of the Public Health Act, 1875) and passages, through which water flows.

The extent of flood control measures necessary in the United States was stressed and illustrated by the following figures:

*Catchment Areas*

| | |
|---|---|
| Thames river at Byron, Ont. | 1,230 square miles |
| Grand river at Galt, Ont. | 1,360 square miles |
| Tennessee river at Ohio | 40,423 square miles |
| Ohio river at Mississippi | 203,782 square miles |
| Mississippi river | 1,231,492 square miles |

Quotations were read from notes on flood control issued by the United States War Department through the office of the Chief of Engineers, Washington, D.C., August 1936 which lists the methods of flood control under:

1. The construction of levees to hold the water off the land and confine it to established channels of discharge.
2. The enlargement of the discharge capacity of the natural channels by various means, such as straightening, widening and deepening; in other words, by an increase of the slope or cross-section of the natural channel.
3. The provision of means for the escape or diversion from the main channels into additional or auxiliary or emergency channels of flood waters in excess of the carrying capacity of the main channels.
4. The construction of reservoirs to withhold, temporarily, from the natural channels water in excess of their discharge capacities, releasing this stored water in such quantity, and at such times, that it may safely be carried in the natural channels.

From the discussion of the above methods in the notes, a conclusion is drawn that the construction of levees is the most direct and surest method but that a combination of levees and reservoirs might insure the most adequate and efficient protection.

Dealing with conditions and present problems in Ontario, the report of Grand River Drainage, Department of Lands and Forests, Ontario, 1932, was dealt with at length. The factors contributing to floods most blamed in the press and elsewhere are deforestation and artificial drainage. From the Grand River Drainage report it would appear that neither of these causes are as basic as they are usually considered. At a time when saturation of a large area exists and a combination of factors tending to produce maxima run-offs is present, serious and dangerous floods will occur little affected by either of the above causes. From a review of the history of the effort of the Grand River Conservation Commission to obtain relief and the legal difficulties and diversity of interest encountered by it, it was suggested that existing legislation in Ontario, namely the Municipal Drainage Act and provincial aid to Drainage Act, be carefully studied to see whether or not by minor amendments these Acts could apply to general river control, and particularly, flood control. The evolution of the Municipal Drainage Act and the extent of its application to the lands at the headwaters of the River Thames in particular, was explained. In respect to the uplands of the Thames river water shed in particular, artificial drainage has been and is responsible for the growth and development of one of the finest agriculture districts in the world and although clearing and draining of the lands speed up runoff, the condition does and must continue to exist, in the opinion of the speaker.

Amendments of 1936 Municipal Drainage Act, particularly section 1 d.d. "'Drain' and 'drainage' work shall include all protective banks, wall, crib works, dykes and other works ancillary thereto," was discussed. In the opinion of the speaker, the control of each western Ontario river devolves both privileges and responsibilities upon all residents within their water shed; that as in England, "Annual Value" should be the basis of assessment of property abutting upon a remedial work; that existing legislation be amended or implemented to provide for the establishment of river boards on arterial streams with responsibility and powers similar to the catchment area boards of England; and that the Provincial and Federal Governments be represented on said boards and contribute as is now done by the province under the provisions of the Provincial Aid to Drainage Act, and by the Federal Government to the extent that control of water is a national problem and according to benefits which might accrue to navigation channels in the future.

An animated discussion followed the speaker's address. About forty-three members and guests were present and many of them were vitally interested in the subject, as they had suffered considerable damage from the recent floods.

Space will not permit the writer giving a full account of the discussion, suffice it to say that the chief interest centred around such matters as government responsibility in matters of this kind, coupled with the question of navigability or otherwise of the streams involved; the provisions and limits of the Drainage Act; the advantage or otherwide of reforestation; the apportionment of cost, etc.

A hearty vote of thanks was proposed by H. F. Bennett, M.E.I.C., seconded by E. V. Buchanan, M.E.I.C., and unanimously carried.

## Moncton Branch

*V. C. Blackett, A.M.E.I.C. Secretary Treasurer.*

The annual meeting of the Moncton Branch of The Institute, was held on May 31st, 1937. The annual report and financial statement were presented and approved. The executive committee reported having held two meetings during the past year and also that there were four meetings of the branch. The membership at the present time consists of fifty-five members. The election of officers for the year commencing June 1st. 1937, took place. The incoming Chairman being E. B. Martin, A.M.E.I.C., and the Vice-Chairman B. E. Bayne, A.M.E.I.C.

## Sault Ste. Marie Branch

*N. C. Cowie, Jr.E.I.C., Secretary-Treasurer.*

A general meeting of the Sault Ste. Marie, Branch of The Engineering Institute of Canada was held in the Windsor Hotel, Sault Ste. Marie, Ont., on June 16th, 1937.

This was a special meeting arranged to coincide with the Semicentennial Meeting banquet being held at that time in Montreal.

A dinner, which was served by the hotel staff between the hours of 7.00 and 8.00 p.m., was enjoyed by the twelve members and guests attending the meeting.

The radio broadcast of the banquet proceedings, which was carried by the Canadian Broadcasting Corporation, was heard by the meeting between 8.00 and 8.30 p.m. Those present had the pleasure of hearing the address given to the Montreal meeting by His Excellency the Governor General of Canada, Lord Tweedsmuir.

Following the radio broadcast of the banquet speeches, the Chairman, Mr. C. W. Holman, A.M.E.I.C., called the meeting to order. Several items of current business were then dealt with by the meeting.

The Chairman then requested Mr. H. O. Brown, A.M.E.I.C., Vice-Chairman of Sault Ste. Marie Branch to take charge of the meeting. Mr. Brown introduced Mr. C. W. Holman as speaker of the evening. Mr. Holman, speaking on the work of the Committee of Consolidation, reviewed the history of the movement toward Consolidation, the work of the committee and the results of this committee's activities, as these have been reported in the Journal.

The meeting fittingly thanked Mr. Holman for his timely and interesting paper which was attentively followed by the members present.

Following the paper a social hour was spent in friendly discussion of a wide range of topics.

## Heat Loss Through Windows

Investigations on the heat lost through windows have been carried out within the past twenty years in the Research Laboratory of the American Society of Heating and Ventilating Engineers, at the United States Bureau of Mines, Pittsburgh, at the Universities of Illinois, Wisconsin, Michigan and California. In Europe, similar work has been reported from the Building and Fuel Research Stations of the Department of Scientific and Industrial Research in England, and in Germany from The Institutes of Technology at Danzig, Darmstadt, Munich, Stuttgart and from other centres.

A small amount of work has been devoted to the determination of the heat transmission of windows, and many tests have been made to determine the amount of heat lost because of the leakage of cold air into the house through the cracks around the sash or window.

A review of the literature on this important subject has been prepared by the Division of Research Information of the National Research Council at Ottawa. The report of 38 pages gives a brief account of recent investigations on heat losses through windows in dwelling houses. It contains a summary of information available, Part I on "Heat Loss Through the Window," Part II on "Heat Loss Through Cracks" and finally a section on "Application and Tests" and a bibliography. Information by means of which the accepted results were obtained is provided which gives a better understanding of the usefulness, shortcomings and the extent to which the results apply to Canada.

Because of the extreme climatic conditions that prevail in this country, house windows should, on an average, provide twice as much heat insulation and admit rather more light than windows in houses located in the same latitudes in European countries.

It is hoped the report will lead to an exchange of opinion as to how the best results may be achieved. Copies of the report will be mailed on request to—National Research Council, Ottawa, Ont.

## Specification for Structural Timber

The Canadian Engineering Standards Association has just issued its publication No. A 43-1937, "Standard Specification for Structural Timber."

In the preparation of the specification, a special endeavour was made to enlist the co-operation of all Canadian interests, and practically unanimous agreement was obtained before publication.

The specification is divided into three parts—Specification proper, Appendix I covering Working Stresses, and Appendix II covering Structural Grades and their Derivation.

The Association trusts that this specification will prove its usefulness, and recommends its adoption by lumber manufacturers and dealers, architects, engineers and construction interests generally.

Copies may be obtained from the C.E.S.A. Secretary's office, Room 3064, National Research Building, Ottawa. The price of the publication is twenty-five cents per copy, but on orders of fifty or more the price is 20 cents per copy.

## Welded Piping Design

Information on design and layout of piping for welded connections is contained in "Design of Welded Piping," a 200-page (6 x 9) booklet containing over 100 figures and tables, distributed by Dominion Oxygen Company Limited, Toronto and published by the Linde Air Products Company, New York.

Subjects treated of interest to engineers are fundamentals of welded joint design; welding metallurgy; standard welded pipe connections; design data on welding cast iron, galvanized iron, stainless steel and non-ferrous piping; advantageous layout; fabrication and erection considerations; welded anchors and supports; and welding speeds.

Features of interest to architects and draftsmen include standard joint designs; typical headers, expansion bends and riser connections; anchors and supports; a typical heating system layout showing symbols for welds; two sample time-saving specifications; and principal dimensions of pipe, flanges and welding fittings.

## List of New and Revised British Standards

(Issued during April and May 1937)

B.S. No.

188—1937. *Determination of Viscosity of Liquids in absolute (C.G.S.) Units. (Revison).*
Provides simple, rapid and accurate methods for the determination of viscosity by the use of relatively inexpensive and readily procurable apparatus.

728—1937. *Precast Concrete Hollow Partition Slabs.*
Deals with the quality of the materials used, dimensions of blocks and tests and methods of testing.

731—1937. *Flexible Steel Conduit for Cable Protection and Flexible Steel Tubing to Enclose Flexible Drives.*
Provides flexible steel tubing suitable for use as a protective conduit for insulated cables and as a mechanical protection to flexible drives.

733—1937. *Density Bottles.*
Gives details of the bottle for determining the density of a liquid together with standard methods for this determination and the measurement of liquid in bulk.

Copies of the new specifications may be obtained from the Publications Department, British Standards Institution, 28 Victoria Street London, S.W.1., and from the Canadian Engineering Standards Association, 79 Sussex Street, Ottawa.

## ERRATA

The following corrections should be made in the text of the paper on "Industrial and Manufacturing Development" by Fraser S. Keith, M.E.I.C., published in the June number of the Journal, pages 365 to 383:

Page 366—2nd paragraph—1st line—should read "Following the unfavourable seven, the five years up to 1884. . . ."

Page 368—3rd paragraph—7th line—should read "Nearly one thousand members or more than thirty per cent. . . ."

Page 372—2nd column—2nd paragraph—14th line—should read "Soap and candle making was the principal item in "Matters—Animal" which includes brush and broom, glue factories and tallow refineries."

Page 374—item "Organized Labour"—Last line of 1st paragraph 437,134 should read 137,134.

Page 377—1st line at top of page to right should read "Noranda development in north western Quebec."

Page 379—item "Primary Textiles"—2nd line should read "in western Ontario."

Page 380—1st paragraph—item "Rayon"—last line should read "persons employed in the silk and rayon industry with a total production of $28,045,000.00."

Page 380—2nd column—last line at bottom of page—omit.

# Preliminary Notice

### of Applications for Admission and for Transfer

July 26th, 1937

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

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The Council will consider the applications herein described in September, 1937.

R. J. Durley, Secretary.

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*The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years inthe case of a candid ate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of,age, and shall have been engaged in some branch of engineering for at least six years which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch ofengineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more year.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard.

**A Student** beshallat least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.

#### FOR ADMISSION

GRAY—HARRY ALDEN, of 1316 Dorchester St. W., Montreal, Que., Born at Pierre. So. Dakota, July 27th, 1908; Educ., B.Sc. (C.E.), Univ. of Man., 1935; 1926-29, rodman, C.N.R.; 1930-35 (summers), rodman, National Parks of Canada; 1935, dftsman. and res. engr., and 1936, asst. engr., Dept. of Public Works, Man.
References: J. N. Finlayson, J. F. Cunningham, N. M. Hall, G. H. Herriot, A. E. Macdonald, E. P. Fetherstonhaugh.

HARRINGTON—ARTHUR WILLIAM, of Elsmere, Albany, N.Y., Born at Watertown, N.Y., June 7th, 1888; Educ., Civil Engr., Cornell Univ., 1909. M.Am.Soc. C.E.; Summers—1906, contractor's asst., N.Y. State highway constrn.; 1907, asst. on borings, N.Y. State Barge Canal; 1908, sanitary inspr., N.Y. State Dept. of Health; —1909, leveler, city engr's. office, Watertown, N.Y.; 1910-12, asst. engr., and 1912-14, supt. of constrn. for L. B. Cleveland, Watertown, N.Y. (charge of station constrn. for N.Y.C. R.R. at Potsdam, N.Y.); 1914-17, junior engr., U.S. Geol. Survey; 1917-18, sec'y. and president, B.B. Culture Laboratory Inc., Yonkers, N.Y.; 1918-20, 1st Lieut., San. Corps, U.S. Army; 1920-22, hydraulic engr., U.S. Geol. Survey, Albany, N.Y.; 1922 to date, district engr., U.S. Geol. Survey, Albany, N.Y., in full charge of all hydraulic investigations of U.S. Geo. Survey in New York State with frequent special assignments in other parts of the U.S.
References: J. B. Challies, O. O. Lefebvre, L. G. Denis, J. T. Johnston, R. G. Swan, R. J. Durley.

HOOGSTRATEN—JACK, of Winnipeg, Man., Born at Winnipeg, Oct. 28th, 1908; Educ., B.Sc. (Civil), Univ. of Man., 1929; 1927, rodman, C.P.R.; 1929, dftsman., Dominion Bridge Co.; 1928, inspr., C.P.R.; 1930, dftsman., Cowin & Co.; 1929-34, instructor, engrg. dept., and 1936 to date, lecturer in civil engrg., Univ. of Manitoba, also at present, instr'man., Winnipeg Electric Co., Winnipeg, Man.
References: A. E. Macdonald, H. B. Henderson, D. M. Stephens, G. McDermid, G. H. Herriot.

IZARD—EDWARD WHITAKER, of Victoria, B.C., Born at Wisbeach, Cambridgeshire, England, Feb. 17th, 1888; Educ., Brighton Tech. College and Glasgow Univ.; Member, Inst. Naval Arch'ts. Assoc. Member, Inst. C.E. (London.) Member, Inst. Engrs. and Shipbldrs. in Scotland; 1906-08, ap'tice, shops, Yarrow & Co., London; 1908-11, drawing office, experimental and research work, Yarrow & Co., Glasgow, and John Brown & Co., Clydebank; 1911-12, i/c erection and running of 27 knot vessel by Yarrow & Co., for Argentine Navigation Co.; 1912-14, design of turbines and internal combustion engines, Diesel engine and torpedo destroyer trials, Yarrow & Co., Glasgow; 1914 to date, works manager, i/c of drydocking and repairs of passenger, cargo and naval vessels, Yarrows Ltd., Victoria, B.C. (1935-37, chairman of Victoria and Vancouver Is. Branch of Candn. Mfgrs. Assn., also member of executive council).
References: N. A. Yarrow, G. L. Stephens, G. Phillips, G. M. Tripp, R. C. Farrow.

WALSTON—TIMOTHY CRAGG, of 265 Dromore Ave., Winnipeg, Man., Born at Winnipeg, Aug. 24th, 1913; Educ., B.Sc. (C.E.), Univ. of Man., 1937. 1929-34, studying arch'ture at Univ. of Man.; At present architectural dftsman., Green, Blankstein, Russell and Ham, Architects, Winnipeg, Man.
References: A. E. Macdonald, H. B. Henderson, W. F. Riddell, R. W. Moffatt, E. P. Fetherstonhaugh.

#### FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

LAWSON—HORACE HETHERINGTON, Major, of 25 Wellington St., Kingston, Ont., Born at Toronto, Ont., Feb. 2nd, 1889; Educ., Grad., R.M.C., 1910. B.Sc., Queen's Univ., 1936. O.L.S.; 1910-15, hydrographic surveying, Dept. of Naval Service, Ottawa; 1917 to date, associate professor of engrg., Royal Military College, Kingston, Ontario, i/c surveying course, mechanics of materials, graphic statics, mech'l. drawing. Also 1931 to date, private work as O.L.S. (*A.M. 1932.*)
References: L. F. Grant, L. F. Goodwin, L. M. Arkley, W. L. Lindsay, N. C. Sherman, A. Macphail, W. Casey.

TOOVEY—THOMAS WILLIAM, of Philadelphia, Pa., Born at Ovington, North'land, England, Sept. 21st, 1899; Educ., Rutherford Tech. Coll., Newcastle, 1914-17: R.P.E. of B.C. (by exam.), 1930; 1914-17, ap'tice, chem. lab., Armstrong-Vickers; 1917-19, Pilot, R.A.F.; 1919-21, research dept., Armstrong-Vickers, Elswick; 1920-21, i/c experimental iron foundry, Elswick; 1923-28, research dept., Can. International Paper Co., Hawkesbury, Ont., i/c of various depts,; 1928-34, chem. engr., B.C. Pulp and Paper Co., Port Alice, B.C.; 1934-37, consltg. work as sulphite expert, i/c constrn. and design of bleach plant, Harmanezer Papierfabrik, Harmanec, Czechoslovakia; At present, technical advisor to chlorine sales, dept. designing bleaching plants and gen. consltg. work, Pennsylvania Salt Mfg. Co., Philadelphia, Pa. (*A.M. 1933.*)
References: E. A. Wheatley, C. C. Ryan, W. A. Bain, S. Wang, S. H. Wilson, J. F. Plow.

#### FOR TRANSFER FROM THE CLASS OF JUNIOR

EVANS—JOHN MAURICE, of 936 Pratt Ave., Outremont, Que., Born at London, England, October 7th, 1905; Educ., B.Sc., (Elec.), McGill Univ., 1929; 1925-27 and 1928 (5 mos), radio testing of equipment, shift engr., beam station, Drummondville, Canadian Marconi Co.; 1927 (5 mos.), erecting fire towers and surveying, Can. International Paper Co.; 1929 to date, with the Shawinigan Water & Power Co., 1929-30, system planning, design of pole lines, transformers, etc., 1930 to date, power sales, industrial location studies, development of new loads, and at present, asst. to manager, Dept. of Development. (*St. 1929, Jr. 1931.*)
References: F. S. Keith, J. B. Challies, J. Morse, J. A. McCrory, J. H. Thompson, C. V. Christie, G. R. Hale.

#### FOR TRANSFER FROM THE CLASS OF STUDENT

BRIDGE—DAVID E., of 50 Fairholt Road So., Hamilton, Ont., Born at Kincardine, Ont., June 23rd, 1906; Educ., B.A.Sc. Univ. of Toronto, 1930; Summer work with Wentworth Motors, Harriston, Ont., North East Electric, Rochester, N.Y., Canadian Porcelain Co., Hamilton, and Detroit Edison Co., Detroit, Mich.; 1929-31, test course, Canadian Westinghouse Company; 1932 to date, instructor in mathematics, Hamilton Technical Institute, Hamilton, Ont. (*St. 1930.*)
References: D. W. Callander, J. R. Dunbar, W. L. Miller, A. R. Hannaford, E. G. Mackay, L. W. Gill, J. F. Bridge.

MACREDIE—JOHN ROBERT CALDERWOOD, of Rexton, N.B., Born at Fredericton, N.B., Aug. 4th, 1910; Educ., B.Sc. (Civil), Univ. of N.B., 1931; 1928-31 (summers), chainman and rodman, C.P.R. constrn. surveys, Sask. and Saint John, N.B.; 1932-34, chainman, land surveys, and private practice, land surveys; 1934, dftsman., D.N.D., Relief Projects; 1934-35, instr'man., baseline surveys; 1935, paving inspr., Milton Hersey Co., with N.B. Highways Dept.; 1936 to date, instr'man., N.B. Dept. of Highways. (*St. 1931.*)
References: E. O. Turner, J. Stephens, C. C. Kirby.

# EMPLOYMENT SERVICE BUREAU

The Service is operated for the benefit of members of The Engineering Institute of Canada, and for industrial and other organizations employing technically trained men—without charge to either party.

*All correspondence should be addressed to*

**The Employment Service Bureau, The Engineering Institute of Canada**
**2050 Mansfield Street, Montreal**

## Situations Vacant

MECHANICAL ENGINEER, with several years pulp and paper mill experience to act as assistant to mechanical superintendent for mill in the province of Quebec. Apply to Box No. 1608-V.

YOUNG CIVIL OR MECHANICAL ENGINEER, for manufacturing firm in Ontario, with at least three years experience in construction work to act as storekeeper, material checker, draughtsman and time clerk. Should be able to read blueprints. Apply to Box No. 1613-V.

MECHANICAL DRAUGHTSMEN. Situations vacant for experienced mechanical draughtsmen. Permanent employment for suitable men. Applications by letter only, giving full particulars of experience. Dominion Engineering Works Limited, P.O. Box 3150, Montreal, Que.

## Situations Wanted

CHIEF ENGINEER-CONSTRUCTION MANAGER, nineteen years construction maintenance operating, industriel plants, steam and hydro power, canals, water supply, etc., estimates, plans, specifications, supervision of construction. Apply to Box No. 36-W.

PURCHASING ENGINEER, graduate mechanical engineer, Canadian. Married, with fifteen years experience covering construction and operation, principally having to do with specification and ordering of equipment and materials for new construction and maintenance. Details upon request. Apply to Box No. 161-W.

INDUSTRIAL ENGINEERING EXECUTIVE, with wide experience including fourteen years in design, construction, maintenance and operation of pulp and paper mills and power developments. Now employed, desires change of location. Apply to Box No. 320-W.

STEAM AND MECHANICAL ENGINEER. Married. Wants position with industrial company within 100 mile radius of Montreal. Would prefer position in charge of maintenance. Can undertake plant layout work, handling steam lines, look after alterations or extensions, make installations on construction work. Previously in charge of similar work and can prepare own drawings. Have good all round knowledge of all trades. 35 years experience. Apply to Box No. 441-W.

CIVIL ENGINEER, B.A.Sc., age 44, structural, harbour, executive. At present designing 32,000-h.p. development in Newfoundland. Available in near future. Apply to Box No. 536-W.

DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aerophotographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.

ELECTRICAL ENGINEER, B.SC., E.E., age 38. Married. Ten years electrical experience; including, one year operation, one year maintenance, and four years on construction of hydro-electric plants and sub-stations. Four years electric maintenance and construction in pulp and paper mill. Also experience on highway construction and Geological Survey Available at once. Apply to Box No. 636-W.

ELECTRICAL ENGINEER, B.SC. E.E. '28. Two years with large electrical manufacturing company including test course, about two years in supervisory operating office of a large electrical power utility, and considerable experience in electrical and mechanical draughting. Location in Ontario preferable. Apply to Box No. 660-W.

ELECTRICAL AND CIVIL ENGINEER, B.SC. Elec. '29, B.SC. Civil '33. JR.E.I.C. Age 29. Experience includes four months with Can. Gen. Elec. Co., approximately three years in engineering office of large electrical manufacturing company in Montreal, the last six months of which was spent as commercial engineer. For the last year and a half employed in electrical repair shop. Best of references. Apply to Box No. 693-W.

YOUNG CIVIL ENGINEER, B.SC. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

MECHANICAL ENGINEER, JR.E.I.C., B.A.SC., Univ. of B.C. '30. Single, age 30. Sixteen months with the Allis-Chalmers Mfg. Co. as student engineer. Experience includes foundry production, erection and operation of steam turbines, erection of hydraulic machinery, and testing texropes and centrifugal pumps. Location immaterial. Available at once. Apply to Box No. 735-W.

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CIVIL ENGINEER, B.SC., M.SC., R.P.E.; Lieut. C.E., R.O. 16 years municipal, highway and construction, 5 years overseas. Married. Read, write and talk French. Will go anywhere. Apply to Box No. 737-W.

RADIO AND ELECTRICAL ENGINEER, B.SC., '31, JR.E.I.C. Single. Age 30. One year and a half actual field experience in power and lighting equipment. Extensive work in telephone and radio layouts in switchboard and installation depts. Particularly interested and experienced in sales and traffic work in telephone and radio company. At present supervisor over sales and service of radio and electrical company. Available on short notice. Location immaterial. Apply to Box No. 740-W.

PLANT ENGINEER or SUPERINTENDEBT, capable of supervising all phases of industrial plant operation, graduate electrical, eleven years diversified industrial experience including test course, four years on large Quebec industrial development, on construction and operation, also six years with prominent consulting firm supervising electrical and mechanical engineering projects. Age 31, single. Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., B.SC. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman. compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

### Employment Service Bureau

The demand for engineers continues, although the number of enquiries received during the month of July did not equal those of the past six months.

During the half year ending July 30th, 1937, The Institute's Employment Service Bureau, placed over 130 engineers, which also means satisfying the requirements of a large number of employers.

Our list of men registered, as available or interested in new positions, is now greatly reduced.

Why not register?

It would be appreciated if those who have recently secured positions would advise the Employment Service Bureau.

MECHANICAL ENGINEER, JR.E.I.C., technical graduate, bilingual, age 35, married, experience includes five years with firm of consulting engineers, design of steam boiler plants, mechanical equipment of buildings, heating, ventilating, air conditioning, plumbing, writing specifications, etc. Five years with large company on sales and design of power plant, steam specialties and heating equipment. Available on short notice. Apply to Box No. 850-W.

STRUCTURAL ENGINEER, B.A.SC., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

CIVIL ENGINEER, B.A.SC. (Univ. of Toronto '27). Age 34. Familiar with house building cost, experience combines structural engineering, construction and house building and improvement, interested in obtaining a connection with firms investigating housing problems, making building loans or with a company engaged in construction or building costs. Apply to Box No. 910-W.

ELECTRICAL ENGINEER, B.SC. (McGill '28), age 34. Experience includes transmission line and rural distribution construction and design. Some installation of motors and equipment, also house wiring. Available immediately. Apply to Box No. 940-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.

## Situations Wanted

ELECTRICAL ENGINEER AND GEOPHYSICIST. B.SC. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics Available on short notice. Apply to Box No. 1063-W.

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No. 1168-W.

ELECTRICAL ENGINEER, B.SC. '34 (Univ. of N.B.), S.E.I.C. Age 24, single. Desires any kind of electrical work. Will consider any location. Apply to Box No. 1262-W.

CIVIL AND ELECTRICAL ENGINEER, Univ. of Man. '35 and '36. S.E.I.C. Experience in irrigation and mapping. Available at once. Location immaterial. Box No. 1418-W.

CIVIL ENGINEER, B.SC. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

CONSTRUCTION SUPERINTENDENT, M.E.I.C. Age 49. Married. Twenty-two years experience as engineer, superintendent and manager in charge of hydro-electric, mechanical production, structural steel erection, also considerable experience in steam plants, combustion, transmission lines, millwright work, complete mine installations, rock work, rock crushers and conveyors. Executive ability. Speaking French fluently. Location immaterial. Apply to Box No. 1482-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.SC. '31 (Univ. of Alta.), JR.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work, location immaterial and available at once. Apply to Box No. 1522-W.

CIVIL ENGINEER, B.SC. '32, S.E.I.C., P.E.N.B., DY.L.S.N.B., age 32. Experience in mining, both coal and metals, private and legal surveys, railroad construction, geology and building construction. At present in private practice in coal mining district. Desirous of changing location for position either in mining field or construction in Canada. or abroad. Apply to Box No. 1562-W.

RESIDENT ENGINEER, familiar with all types of surveys and construction work including, railway, roads, irrigation, drainage, buildings and air ports. Executive ability. Had charge of several large projects. Intimate knowledge of reports and estimates. Available immediately. Any location. Apply to Box No. 1567-W.

CIVIL ENGINEER, B.SC. '17, O.F.E. Married. Executive and administrative experience. Extensive office and field experience in harbour works, dredging; both steam and electric railways in location, construction and maintenance; telephone works in design, construction and maintenance of pole lines, wire, cable and conduit; highways in location, construction and paving; municipal works in roads, sidewalks, sewers and water mains. Intimate knowledge of estimating, unit costs, cost accounting and analysis. Some knowledge of air conditioning. Willing to locate anywhere. Available at once. Apply to Box No. 1587-W.

ELECTRICAL ENGINEER, B.SC. '27 (McGill), A.M.E.I.C. Age 36. Married. Bilingual. Three years experience in telephone work (installation of manual and automatic exchanges). One year electrical prospecting. Nine years experience with electrical power company. Apply to Box No. 1601-W.

EXECUTIVE TOOL AND PRODUCTION ENGINEER, desires to make a permanent change, graduate in mechanical (Queen's '23), A.M.E.I.C., married. Well abreast with modern production methods and present competition. Competent supervisor of tool and die design and construction; operations and methods, plant layout, efficiency and time study, toll and production estimating, tooling development foundry, machine shop and designing experience. Best of references. Apply to Box No. 1653-W.

ENGINEER, age 44, seeks connection as chief or plant Engineer, with pulp and paper, or textile concern. Apply to Box No. 1662-W.

## Water Levels in the St. Lawrence Ship Channel

In January, 1934, Hon. Alfred Duranleau, then Minister of Marine of the Federal Government of Canada, appointed an interdepartmental board with instructions to "gather all necessary information and data, and after consideration and study to report" in writing "its conclusions as to the cause of low water conditions in the St. Lawrence Ship Channel and the Harbour of Montreal and what action, if any, should be taken to improve these conditions," The Board has now made its Report to Hon. C. D. Howe, Minister of Transport, in whose Department the old Department of Marine has been merged. It is dated January 19th, but has only recently been made public; it is a voluminous document, and for this reason is not to be printed for public circulation. The Board is unanimous as to the causes of the low water level conditions, but not as to possible remedies, five members presenting a majority finding which recommends further dredging, and two other members presenting separate minority reports recommending in one case a gradual programme of development, and in the other case delay in the carrying out of all major work until economic conditions will justify the expenditure involved.

The third, and main, part of the Report, is a record of the many studies and investigations made into possible improvements of the ship channel below Montreal. It was in connection with these that 17,500 ft. of borings were specially made, and many other field studies were prosecuted. It may be noted for convenience that the length of channel between the Upper Harbour at Montreal and Quebec is just over 160 miles, about one-third of this having an effective tide, although tidal influence does reach to Montreal, being negligible, however, for all the upper reaches of the ship channel. The studies of the Board were into three possibilities; regulating dams with locks; regulating weirs and training works; and dredging.

Three proposals for the construction of regulating dams with locks were investigated in some detail at mileages 145, 110, and 11 (all from Montreal, as are the mileages mentioned hereafter). Estimated costs were 58, 53, and 37 million dollars respectively, excluding possible damage along the river banks. All dams were designed with twin locks 900 ft. long and 90 ft. wide. The resulting rises in water level at Montreal would be in the nature of 1.3 ft. for the first two proposals, but more in the case of the third proposal. All were discarded by the Board, however, as being definitely uneconomic, when compared with dredging, and especially in view of the possible land damage along the banks, and interference with the operation of ice-breaking operations in the early spring. The Board also considered various proposed steel movable dams, and other ingenious solutions to the problem, but dismissed all in view of alleged difficulties and hazards of operation, in addition to their doubtful economy.

Eight separate proposals for the construction of weirs were considered in detail, at locations varying from Champlain, 94 miles below Montreal, to Pointe au Trembles, at the foot of the Island of Montreal, some as weirs constricting the flow through openings in them to be built in deep uniform sections of the channel, and some as dams cutting off altogether the low water from channels now carrying a part of this flow around some of the many islands which are situated in the river bed. Estimated costs varied from 600,000 dollars to 7,500,000 dollars, the resulting gains in water level at Montreal varying also to a marked degree. The Board was not able to recommend the serious consideration of any one of these proposals, on the grounds that several were clearly uneconomic, while others were thought to be dangerous from the point of view of either increasing ice troubles in the early spring, or else making navigation in the restricted portions of the river hazardous.

The Board considered the submerged rock weirs which now exist in some of the channels into which the river divides at the head of Lake St. Peter in the vicinity of the port of Sorel; they were constructed in 1928-1931, and have recently been raised, with consequent serious and detrimental effects to navigation in view of increased channel velocities and erosion of adjacent land. The Board is unanimours in recommending that one of the existing weirs should be removed, and all the others lowered to 2 ft. above low-water level with one new small weir to be built across a side channel, the net results of which will be to reduce the improvement at present given at Montreal by these weirs (about 5 in.) by 20 per cent, with consequent benefit to navigation. The estimated cost of the works proposed will be 835,000 dollars.

The Board also considered in detail a proposed scheme of training works centring on Ile Ste. Therese, a large island located in the main channel at the foot of the island of Montreal. By means of two diversion dams, concrete structures containing Stoney sluice gates, across two small existing channels and 16,000 ft. of separation dyking, constructed as rock-filled concrete cribs resting on timber bearing piles, protected by rock fill, the river section could be divided into two approximately equal parts for the discharge of flood flows, whereas at low water periods it is calculated that the works would have the effect of raising the water level in Montreal Harbour by 1.65 ft., with only minor local inconveniences occasioned by the obstruction to cross-river traffic provided by the separation dyke. Sixty-one Stoney sluice gates, each 50 ft. wide, would be necessary for the diversion dams to be operated at high water periods. The estimated cost of the works is 10,508,000 dollars, the location being between mileage 11 and mileage 28 from the upper end of Montreal Harbour.

Dredging was considered in the light of the work done up to the present, one of the Board's first dredging studies being an investigation of the cost of completing the 35 foot project, to the old 1897 datum. It is estimated that this can be done in 1937 if funds are available at a cost of 1,600,000 dollars. The Board next considered what it would cost to dredge a 35 ft. channel below the newly adopted low-level datum of the Hydrographic Service based on the low-water levels of 1934, 2 ft. below the 1897 datum. This cost was found to be 13,521,000 dollars if completed to Quebec, but only 6,559,000 dollars if carried out as far as Cap de la Madeleine, below which tidal influence is felt so that ships of deep draught, at periods of low water, could wait here if necessary and proceed as the tide rose. The Board suggests as a result of its studies that such a channel will enable ships drawing 31½ ft. to go in and out of Montreal Harbour under all combinations of poor conditions except the most extreme.

The Board also considered, and unanimously recommended, that a realignment of the main ship channel should be dredged opposite the port of Three Rivers. The present channel is adjacent to the north shoreline, on which are located the main wharves of the port, some of which cannot be effectively used, and in consequence of which a slow order limits the speed of all vessels in this stretch of river. By the dredging of a new cut in mid stream, this disadvantage could be avoided; the cost is estimated to be 500,000 dollars.

Following a recapitulation of the schemes investigated, and a summary statement of various combinations of schemes which might be adopted, the Report concludes with some relevant studies of wharfage capacity in the harbour of Montreal. The harbour contains some ninety-nine berths, with a total length of 47,820 ft. Of these all built since 1910 were designed for an ultimate depth alongside of about 32½ ft. below the 1934 low-water datum plane. "However," the Report continues, "it must be pointed out that weaknesses have developed in the designs used, and none of the adjacent berths can now be deepened to the full depth contemplated, except King Edward Pier, the greater part of which has been reconstructed with reinforced concrete cylinders to rock." This is clearly a complicating factor, although contracts have been let recently for the reconstruction of several of the more important wharves so as to give a depth of 33½ ft. below the 1934 datum. A tabular statement is presented which shows that only about 20 per cent of the total wharfage will give depths along-side of 32½ ft. or over (corresponding to a depth of 34 ft. in the channel), unless the water levels in the harbour are raised by means of such works as those proposed at Ile Ste. Therese. If these training works were constructed, the percentage would increase to 46 per cent.

The final recommendations on this third, and vital, part of the Report are not unanimous, apart from agreement as to the necessity for the small works at Three Rivers (dredging) and Sorel (reconstruction of submerged weirs).

The general subject of water levels in the St. Lawrence has long been a vexed question. In the present Report it is noted that a Commission of Inquiry was appointed as far back as 1913 with regard to the question. An interim report was issued in 1915, and studies continued until 1919, but no final report was submitted. Since that time, the matter has been often to the fore in public discussion, especially during recent years. The Report now issued will go far to setting at rest many of the uninformed ideas which have found expression from time to time, and although the findings are so divided as to the solution of the problem, it is to be hoped that the information assembled by the Interdepartmental Board will go far towards bringing about a final solution of a problem which, in its effects, far transcends the immediate locality of the ship channel, being in every sense a matter of concern to the whole Dominion of Canada.—*The Engineer.*

## Second Symposium on Water Hammer (New York, Dec. 9th and 10th, 1937)

In 1931 the then status of water hammer theory was reviewed by a committee appointed by the American Society of Mechanical Engineers, Hydraulic Division, and as a result of their work a symposium on water hammer was held in Chicago in 1933. Eight papers dealing with various aspects of water hammer were presented. As a result of the widespread interest aroused by this work, a second symposium on water hammer will be held in New York on December 9th and 10th, 1937, under the auspices of the same committee, with the co-operation of the American Water Works Association. The committee includes associated members from the Engineering Institute of Canada, Professor Robert W. Angus, Hon M.E.I.C., and Professor F. M. Wood, A.M.E.I.C., and also from Australia, Brazil, France, Germany, Italy and other countries.

Contributions from engineers interested in the subject in the form of comments or suggestions, papers or reports, will be welcomed, and should be sent to the chairman of the Hydraulic Division, A.S.M.E., c/o United Engineers and Constructors Inc., 1401 Arch St., Philadelphia, Pa.

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## Contents



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# THE ENGINEERING JOURNAL

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## Growth and Spread of Arc Welding in Canada

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada in June 1937, in Montreal.**

SUMMARY.—**Outlines the development of arc welding in Canadian shops with notes on electrodes, fabrication procedure, stress relief, X-ray examination, and the training of operators. A detailed analysis of various types of joints is given.**

The Semicentennial Anniversary of The Engineering Institute of Canada, founded in 1887 as the Canadian Society of Civil Engineers, is taking place just about fifty years after the discovery of metallic electrode arc welding.

The process of arc welding, although discovered so many years ago, remained comparatively unknown until the urgent requirements of a world at war unveiled the merits of the tool and placed it in the foreground as a very convenient way to make repairs in place, saving valuable time by avoiding dismantling and replacement. At that time, and for several years later, the idea that a metallic electrode arc welding set was essentially a repair kit persisted and it was valued more or less in proportion to its user's success in application.

Gradually however, with succeeding years, engineers have learned that arc welding is not only a first class repair tool but that it may be used advantageously for permanently joining connecting parts of major structures.

In its evolution it has grown from a handy tool for the repair of defective steel castings to the means for connecting rolled steel parts to replace castings. It has developed from an easy way of repairing boiler tube sheets to a method by which the best quality of important pressure vessels are constructed. From its early use as a convenient way to plug misplaced holes it has risen in dignity until it is now playing a major part in the fabrication and erection of steel bridges and buildings. Its valuable features have made possible the development of original types of design to accomplish increased economy of material and amazing improvement in appearance.

The growth and spread of arc welded construction in the last few years have been almost sensational although, as previously stated, it was considered for so many years only as a superior method of repair. As a matter of fact it is still regarded as no more than that by a few; but those who have had the opportunity to use it as a fabrication agent to any great extent are very appreciative of its structural worth.

A brief outline of the experiences of a few Canadian companies in their development of arc welded fabrication will illustrate the strides made in the last ten years.

The Canadian Westinghouse Company began with a single welding set in 1923, using it largely for repair work. By 1925 it was necessary to find larger welding quarters, and again in 1927 the increased part of their product fabricated by the arc welding process necessitated further expansion. In 1930 still greater enlargements were made. The floor space used for welded construction at that date had increased more than 600 per cent since 1923. During this period the number of welding units had increased from one to twenty-five, and there are probably thirty in use to-day.

Some idea of this company's new trend of design may be given by a description of the changes made in large A.C. generators.

Starting in 1926 with relatively unimportant parts such as welded stairs and platforms, every succeeding order saw more and more welded fabrication. The main and exciter frames soon followed the platforms, with the lower bearing brackets as the next step. By 1930 the upper brackets and oil pots had become welded and in 1931-32 the *last casting, the spider,* became a welded assembly. Since then these larger machines have been designed for entirely welded fabrication.

The company's developments in the transformer field advanced rapidly with the advent of welded tanks. Welded construction of end frames, bases, and covers, etc., became standard practice just as quickly as the personnel could be trained and the shop equipped for it.

Their standard designs for synchronous motors from 100 to 3,000 h.p. are for welded fabrication and the spread of this type of construction for this company's wares grows daily.

The history of the growth and spread of arc welded construction in the shops of the Canadian General Electric Company Limited is similar to that just described, but is none the less wonderful.

It is only about twelve years since this company's use of arc welding was almost exclusively as a means of repairing and making small parts, mostly for factory maintenance.

Since then rapid progress has been made, until to-day the parts of large A.C. generators such as stator frames, upper and lower bearing brackets, rotor spiders, bases, etc., are all of welded construction.

In fact the size of structures now made by this company by means of welding is limited only by shipping clearances.

Probably one of the greatest contributions made by welding to the construction industry is in connection with larger rotating parts. On large generators, cast rotor spiders are very heavy and expensive, requiring costly patterns, foundry uncertainties and expensive machinery. With the development of welded designs thinner parts are used, allowing a considerable saving in freight in addition to that made by the elimination of patterns, excess metal, machining, etc.

Fig. 1—Arc Welded Transformer Tank, Canadian Westinghouse.

While the Canadian Locomotive Company Limited does not yet build standard types of steam locomotives of entirely welded construction yet the use of arc welding has increased greatly in their fabrication until now there are over one hundred and fifty different electric welding operations.

Thirteen welding units are necessary to meet the growing requirements of arc weld constructed work in this company.

At the Montreal Locomotive Works Limited, arc welding plays a similar part. Locomotive staybolt caps and sleeves, side sheets of fire-boxes and syphons are electrically welded.

The motive power departments of the railways use welding extensively.

In the Canadian National Railway shops most of the light plate work such as cabs, smoke deflectors, stoker conveyor troughs, tender tanks and swash plates, steps, etc., are fabricated by welding.

Riveted seams in their locomotive fireboxes have been completely superseded by butt welded joints and, in addition to this, the beads of back ends of all boiler flues are welded to the flue sheet.

Fractures in main frames or truck frames, bolsters or other steel castings are repaired by welding and bronze hub covers are welded to cast steel driving boxes.

Parts which are subject to excessive friction and wear, such as conveyor screws, intermediate buffer blocks, chafing plates, etc., are built up to standard dimensions by arc welding as engines pass through the shops.

In the Angus shops of the Canadian Pacific Railway the growth of the application of arc welding has become so great that now it is difficult to comprehend how operations were carried out efficiently without its use in the past.

Whereas in the early days arc welding in this shop was confined to the output of one electric welding set, there are to-day 40 arc welding sets in constant use in addition to gas equipment.

The early experiences of the Dominion Bridge Company Limited were like those of all the others. It first used arc welding commercially in the fabrication of light storage tanks. Other types of welded structures soon followed, notably embedded parts for hydraulic gates and parts formerly of cast steel. Arc welded products of the Dominion Bridge Company Limited now include pressure vessels of all descriptions up to those of the highest code classificiations requiring controlled oven stress relief and X-Ray examination. Mechanical parts such as gear blanks, large gear boxes, lift bridge sheave drums, crane trolleys, etc., are manufactured by this method. Welded steel structures for buildings of composite construction are a regular standard office and shop procedure; and bridges are fabricated by arc welding when that type of structure best suits all the requirements.

In 1917 the arc welding equipment of this company consisted of two old box welders taking current directly from the power line and fluctuating with every variation in line load.

To-day it has 45 machines in daily and often nightly use in its Lachine plant and each of its branches throughout Canada has arc welding facilities in proportion to its relative tonnage capacity.

The Lachine plant is equipped with two stress relieving ovens, the larger one having an end opening of 14 ft. by 17 ft.

The plant also has a 300,000-volt X-Ray machine capable of penetrating 3 in. of steel.

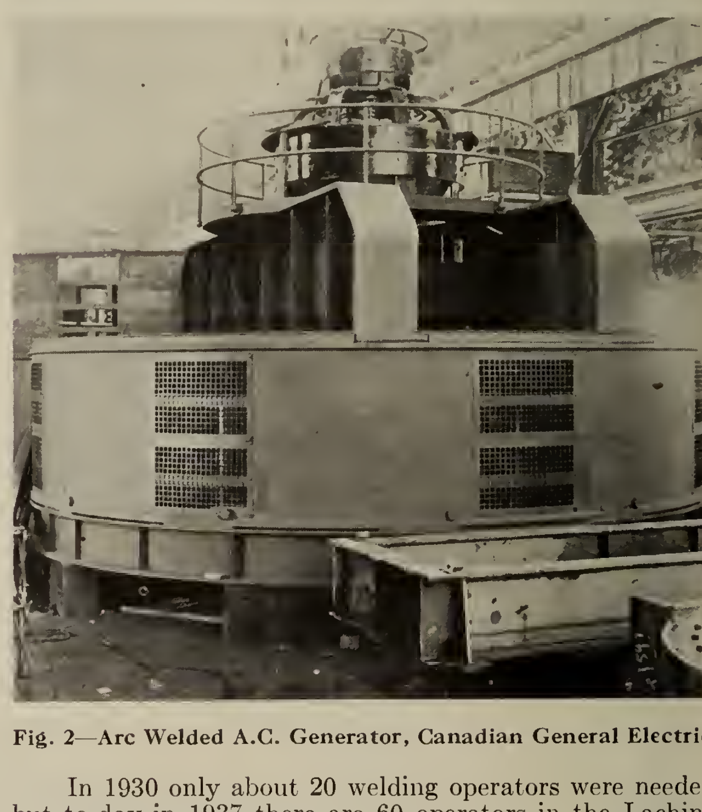

Fig. 2—Arc Welded A.C. Generator, Canadian General Electric.

In 1930 only about 20 welding operators were needed but to-day in 1937 there are 60 operators in the Lachine plant with several more in training.

### Reasons for Accelerated Development

The greatly accelerated growth of arc welded construction may be credited to improved welding machines, better electrodes, an increased knowledge of fabrication procedure, and better comprehension by engineers of the fundamental requirements necessary for its successful employment.

The builders of welding machines have supplied equipment to meet advancing requirements. Changes have been made chiefly to take care of the developments in types of electrodes.

Formerly 200 ampere machines with open circuit voltages of 25 were sufficient for the use of small bare electrodes. With the development of heavily coated electrodes, however, 300 and 400 ampere machines with open circuit voltages of 40 became necessary.

A.C. machines are being used much more than previously. Their chief advantage may be that they eliminate arc blow, but some authorities believe that they more consistently deposit a dense weld.

Electrodes have been so much improved that a choice may be had for any purpose. All grades from bare wire to the heavily coated electrodes used only for down-hand welding can be obtained. When other conditions are right these latter electrodes will produce joints equal in all respects to the parent metal. i.e. equal specific gravity, tension, shear and bending values, elongation, toughness and fatigue resistance. Some produce a molten metal surface of the meniscus type which helps greatly in obtaining pure weld metal by eliminating undercutting in grooves and thereby minimizing the necessity for chipping.

Electrodes may be divided into three main classifications.

One class of electrode is commonly known as "bare," but it always has a very light sull or lime coating. Although this coating is necessary, it exists only for arc stabilization.

Another class of electrode is one with a coating containing carbonaceous material which produces a gaseous atmosphere when burning. This electrode coating generates a gas which shields the arc from the atmosphere and leaves a slag which protects the molten metal. Electrodes of this type may be used for vertical fillet and vee welding as well as on the flat.

A third type of electrode is coated with a composition essentially of a mineral nature. Because of the relatively slower melting of the covering a cup forms at the tip of the electrode shielding the arc from the air and reducing heat losses. The slag which forms on the surface of the molten and hot metal in the groove acts as a blanket to insulate the weld while cooling. This type of electrode is essentially for welding in a groove in the flat position. When used by experts it will make very fine fillet welds on the flat, but this takes great skill.

### Fabrication Procedure

In the construction of arc welded parts the members of the shop staff have had to develop procedures to keep residual stresses at a minimum, control distortion, prevent cracking while welding, etc., in addition to fabricating in an efficient and economical manner by the new method.

They have learned when and how to pre-heat to prevent cracking, to make separate sub-assemblies as far as possible before assembling to the larger structure, and to use only sufficient current for the required fusion.

When it is necessary to clamp an assembly firmly in order to prevent distortion while welding, the whole is pre-heated if possible and the welds are peened to eliminate or minimize residual stresses.

If conditions permit, however, instead of clamping they provide guides to allow pieces to change in allowable limited directions. When they can, they prefer to allow controlled freedom of movement in as many directions as possible.

In welding an assembly they start at the centre and weld outwards; and they have learned to make the heavier welds or those which will strain the most, such as butt welds, first and to finish with the lighter welds.

Fig. 3—Arc Welded 60-Ton Crane Trolley Frame.


Fig. 4—Arc Welded Refinery Vessel 12 ft. dia. by 1⅝ in. Shell.

Where parts to be welded have several butt joints meeting at right angles at various points in the structure all the joints in one direction are welded first and then the remaining seams are welded from the centre outward.

These and many other schemes have been developed by the shops to control the quality of the product.

The development and use of rotating and other equipment for turning parts in the shop to positions for down-hand welding in order to take advantage of large electrodes and high currents has done much to promote welded fabrication.

### Stress Relief

In important pressure vessels, and mechanical parts designed to operate under conditions of dynamic loading, it is now common practice to relieve stress at a temperature of about 1,100 to 1,200 deg. F. This is done in large ovens capable of containing vessels or other structures about 12 ft. wide by 14 ft. high. The cross sectional capacity is governed by railway shipping clearances. By this operation residual stresses are reduced to a minimum and superior structures are produced.

### X-Ray Examination

For some types of vessels such as power boiler drums, high pressure and high temperature oil refining vessels, etc., it is required to produce proof of the quality of the welding in the joints.

This is accomplished by means of X-Ray examination. When this is done exographs of every foot of butt welding are made, and each film is examined carefully. When defects are found the faulty metal is chipped out and rewelded. The repaired portion is then re-exographed and the new film is studied to discover whether or not the new weld is satisfactory. By this means it is possible to produce practically perfect structures.

### Training of Operators

To-day with the increasing demand for welding operators, most large companies find it necessary to train their own welders.

This is done by running regular training schools where men are given a set course. This generally takes about three months, after which the newly trained men are put to work in the shop tacking and doing a certain amount of unimportant welding. By degrees they are schooled on actual work, but under careful supervision, advancing stage by stage until they are thoroughly trained.

All welders have to pass qualification tests and they are graded accordingly. Those who work on pressure vessels are specially qualified in accordance with the requirements of government departments having jurisdiction.

### Joints

The outstanding development in welded fabrication is in some measure due to the better understanding by engineers, in both office and shop, of the right way to design, detail and build structures in a manner suitable for arc welded construction. Original designs are now made for welded structures rather than designs for riveted structures with arc welding substituted for riveting.

Something of what the engineer should know about welding in order to design welded structures of various kinds is indicated in the following discussion of joints.

The design of joints requires a great deal more than merely to provide for a definite amount of weld metal proportioned by dividing a calculated amount of stress by a specified unit.

Engineers appreciate that under some circumstances certain types of joints may involve unnecessarily high shop and field costs; and they must be capable of choosing the best joint for any particular condition.

The preparation of the material for certain kinds of joints is as important as the actual operation of welding; and the assembler controls the quality of the joint as much as the welding operator. The assembler must be careful to leave proper clearances, allow sufficiently for expansion and contraction, secure properly to prevent distortion and when necessary pre-set to allow for distortion.

To get a clear understanding of the comparative analysis of the joint types to follow it may be well to accept the general conditions 1, 2, and 3, which follow:

1. The best condition for welding is down hand on a flat surface (Fig. 5). Penetration is greatest under such circumstances because the current is concentrated over the whole area of the electrode cross section and all points on its surface are equidistant from the surface of the flat plate. The deepest penetration is directly under this area and decreases to zero at the boundaries of the arc flare.

2. Assume penetration in a vee (Fig. 6) or groove to be not more than to the root of the vee or groove, i.e. to the shoulders of the prepared edges. At times, somewhat more penetration than this may be obtained, but the assumption is safe and reliable.

3. The arc will take the shortest path and therefore may leave an unfused part when conditions are favourable for it as in Fig. 7.

In the following comparative analyses of joints it is assumed that conditions 1, 2, and 3, previously stated, are correct. Although all of the joints discussed may be used in construction under right circumstances they should be chosen to suit the specific work they have to do and the position in which they must be made.

Figure 8 indicates two $\frac{3}{16}$-in. or lighter plates with square edges butted closely together. On the basis of our assumption (1) this should give a full penetration as electrodes of the right size will penetrate $\frac{3}{16}$-in. under suitable conditions; in practice however, full penetration is impossible to obtain without the use of a backing bar. If full penetration were attained the plate would be melted through and if it were not melted through there would not be full penetration.

This joint, however, may be satisfactory for some purposes where load stresses and distortions are negligible.

Where plates over $\frac{3}{16}$-in. in thickness (Fig. 9) are connected in the manner shown there will undoubtedly be incomplete penetration, as $\frac{3}{16}$-in. is about the maximum penetration obtainable with an assurance of sound welding.

At the unfused portions of the abutting plates there is a point of very severe stress concentration. Authorities have stated that the stress concentration at this point under tension loading is from eight to twelve times the average stress.

Under certain circumstances this would appear to be a very dangerous joint, particularly in tension or bending.

The joint shown in Fig. 10 is excellent when special care is taken and sufficient consideration is given to electrode diameter, current, arc blow, length of seam and ease of execution. These special conditions are necessary to make such a seam with perfect penetration and without slag.

Though structurally sound this seam, even with perfect penetration, would not pass some codes where chipping is

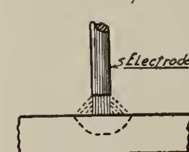

FIG. 5

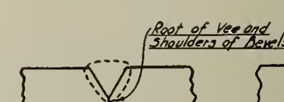

FIG. 6

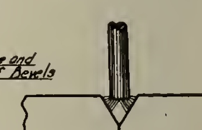
FIG. 7


FIG. 8

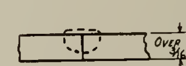

FIG. 9

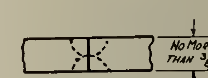

FIG. 10


FIG. 11

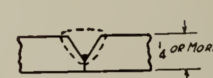

FIG. 12


FIG. 13


FIG. 14

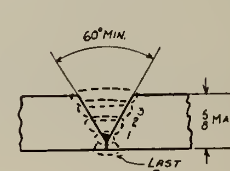

FIG. 15

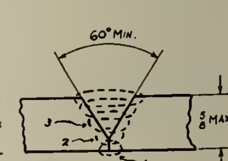

FIG. 16

specified. This weld may be made to satisfy such codes if one side is welded and the other side then chipped to solid weld metal and completed.

The weld as shown is good in tension, compression and bending and the square edges are particularly satisfactory for assembling.

Although the joint pictured in Fig. 11 will not have perfect weld throughout because of a segregation of slag and drippings at the bottom of the first pass it may be very satisfactory for cases where full strength is not the main feature. It is excellent for fast production, but it would not be acceptable to some codes because of the inevitable entrapped slag.

Figure 12 depicts a joint ¼-in. or more in thickness, welded from one side. Referring back to Fig. 6 and our condition 2 it will be noted that complete penetration is impossible here. This joint may be dangerous under load in a like manner to that shown in Fig. 9.

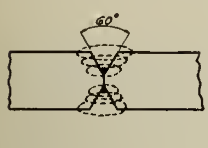


FIG. 17

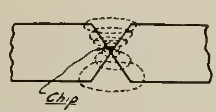


FIG. 18

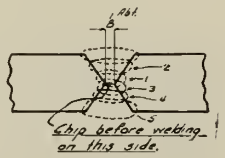


FIG. 19

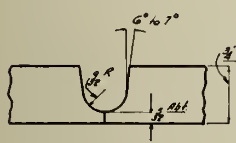


FIG. 20

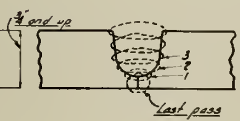


FIG. 20A

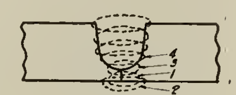

FIG. 20B

To make the joint in Fig. 13 practically perfect when welded from one side it is necessary to draw a light bead at the root with a small electrode very expertly handled. Subsequent passes may be made with larger electrodes.

This type of joint, however is difficult to assemble and provides very little resistance to contraction. There is likely to be an over-lapping of the adjoining edges with a consequent lack of penetration.

A perfect joint may be made by welding from one side when made as shown in Fig. 14, using a backing bar. The plates should be bevelled to a very small shoulder and be separated about the diameter of the electrode—slightly less for down hand and a little more for vertical welding.

In Fig. 15 the joint shown is bevelled from one side, leaving very small shoulders. The first pass is to the bottom of the vee and a small amount of slag may be trapped at the root. After the grooved side is completely welded the back of the joint is chipped to remove the enclosed slag, and then the last pass is run.

This joint can be made perfectly and can meet the highest code classifications.

The joint in Fig. 16 is almost the same as that shown in Fig. 15 and is of practically the same value regarding freedom from impurities. It differs in that the sequence of the passes does not require chipping. Because some codes arbitrarily specify the chipping of welds of certain classifications the use of this joint might be prohibited in many pressure vessels. It is excellent for vertical welding.

Figure 17 shows a joint which is very unreliable as far as full penetration is concerned, even though welded from both sides. Impurities will be left at the bottom of the grooves and they cannot be removed satisfactorily by chipping. There will almost assuredly be no penetration for the depth between shoulders.

A joint of the type shown in Fig. 18, bevelled from both sides and with the plates closely butting, which is required to be entirely free from entrapped impurities, will require chipping. Chipping of course is commonly done in high class work, but in this case too much work will have to be done as a great deal of parent metal will have to be chipped from the sides before the slag at the bottom can be removed and solid weld metal reached. A U-nosed chisel has to be used and it must be wide enough to take care of side undercutting caused by arc flare.

However, with the plates bevelled from both sides as in Fig. 19, and the edges separated as shown, it is possible and not too difficult to obtain a weld perfect from all standpoints. There may be some difficulty in running the first pass. After one side is completed it is necessary to chip to solid weld metal before making the first pass in the second groove. If much trouble develops in placing the first pass in the first groove very deep chipping will be necessary. The chipping however, is easy of access because there is ample room.

When we reach plates of ¾-in. and upward in thickness the most satisfactory form of joint preparation is that shown in Fig. 20. Welds of the highest quality, entirely free from slag and porosity can be obtained. Satisfactory joints may be made from the styles shown in either figures 20A or 20B.

For the method shown in Fig. 20A it has been found beneficial to run a very light preliminary pass on the ungrooved side of the joint. This is helpful in preventing subsequent cracking during welding and also in controlling the arc blow. After the groove is completely welded the back must be chipped to solid metal. This of course cuts out all the preliminary backing bead involving a small waste of weld metal. Where this joint is welded in the sequence indicated the chipping must be done from the inside if the structure is a vessel. Very often this is awkward and difficult, especially in small vessels. Three inside operations are necessary, i.e., welding, chipping, welding.

When the joint has the welding passes made in the order shown in Fig. 20B a perfect joint can be obtained with a little more ease than by the method shown for Fig. 20A.

Two passes are first made on the ungrooved side and then the bottom of the groove is chipped from the outer or grooved side. The second pass of weld has provided plenty of metal to stand thorough chipping and leave enough material for an efficient backing for the groove weld.

The first pass is easy to make because it is against the flat plate, hence there will be a minimized danger of impurities. On vessels the only inside work involved is the laying of the first two passes of weld. The subsequent

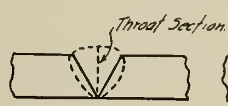


FIG. 21

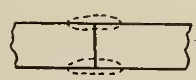

FIG. 22

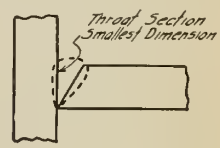


FIG. 23

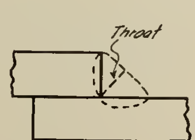


FIG. 24

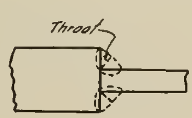


FIG. 25

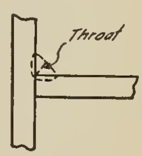


FIG. 26

chipping and all the groove welding is done from the outside under conditions of much more ease and comfort for the operator.

So far this has proved the most satisfactory method of making high class welded joints in thick metal.

The joints so far compared are all of the butt type and are the kind generally used in the construction of pressure vessels. Structural steel parts are more often connected by means of fillet welds. In general a butt weld may be described as one in which the throat section is normal to the sections joined as in Figs. 21, 22 and 23, while in a fillet weld the throat section is inclined to the surfaces of the sections joined as in Figs. 24, 25 and 26. Butt joints are now nearly always made with covered electrodes.

Bare electrodes are still used a great deal for making fillet welds but many companies are rapidly reaching the point where they use only covered rods for that purpose.

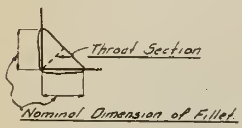


FIG. 27

FIG. 28

FIG. 29

The following comments on fillet welds therefore will have to be based on a consideration of both types of electrodes.

*Fillet Welds—Bare Electrodes—One Pass—(See Fig. 27).*

In earlier days of welding it was very common practice to use only one size of electrode, generally $\frac{5}{32}$-in. diameter, for most classes of work. This limited the size of the one pass fillet to about $\frac{1}{4}$-in. for good welds. Danger lay in attempting to make larger single pass welds with this size of electrode. To-day, however, *the size of the electrode is chosen to suit the fillet* to be made.

Bare wire electrodes of $\frac{5}{32}$-in. in diameter will make one pass fillets of about $\frac{1}{4}$-in., those of $\frac{3}{16}$-in. diameter will make a $\frac{5}{16}$-in. fillet, and $\frac{1}{4}$-in. electrodes will make $\frac{3}{8}$-in. fillets. *The choice of electrode size also depends on the thickness of the materials* to be joined.

Large electrodes cannot be used on thin plate because the heat required for the electrode will be too great for the metal.

When making fillet welds it is essential that fusion must be complete to the root. To accomplish this the welder must not allow the root to become cool at the point of deposition at any time during the operation. To maintain this condition it is necessary to vary the electrode to suit the fillet.

The difficulty of obtaining full root penetration with bare electrodes varies with the position of the fillet. When the weld is being made in a vertical position the root condition is easily satisfied.

*Fillet Welds—Bare Electrodes—Two Pass.*

In making two pass fillet welds with bare wire a very light string bead is first drawn along the root. This light bead easily affords full root fusion. The second pass is very easy to run because the ordinarily difficult root penetration has already been accomplished and arc blow conditions have been bettered.

*Fillet Welds—Bare Electrodes—Multiple Pass—(See Fig. 29).*

To make multiple pass, bare wire, fillet welds the same conditions for root penetration are observed as for two pass welds. Subsequent passes usually do not give much trouble, but particular care must be taken to get full penetration on horizontal surfaces.

Bare wire fillet welds may be made in all positions, i.e., flat, vertical and overhead.

*Fillet Welds—Covered Electrode—One Pass.*

With covered electrodes fillet welds on the flat may be made very easily. Larger electrodes may be used when covered, the greater heat being absorbed in making the molten metal more fluid.

The welding technique is of the simplest possible kind—a straight draw with high current.

Root penetration does not give the same trouble as with bare wire since arc blow is lessened and the molten metal is in a more fluid state because of the greater heat.

Fillet sizes of $\frac{3}{16}$-in. to $\frac{1}{4}$-in. may be obtained with $\frac{5}{32}$-in. dia. electrodes; $\frac{1}{4}$ to $\frac{5}{16}$-in. with $\frac{3}{16}$-in. dia.; $\frac{3}{8}$-in. with $\frac{1}{4}$-in. dia., and $\frac{7}{16}$ to $\frac{1}{2}$-in. with $\frac{5}{16}$-in. dia. electrodes.

*Fillet Welds—Covered Electrodes—Multiple Pass.*

Two pass fillet welds are rarely made when covered electrodes are used, since it is difficult to weave a second pass. Where very large fillets are necessary three or more passes are used.

With correctly chosen covered electrodes fillets are easily made in the flat position, but when they are used for vertical welding, the current must be cut to control the molten metal, as covered rods form an extremely fluid puddle.

In welding in a vertical position the general movement of the electrode may be either downward or upward.

It is difficult to obtain a good weld by downward vertical welding, but if it can be made the crystalline structure will be excellent. To make it the weld is deposited in thin layers and must proceed fast enough to keep ahead of the slag. The successive thin layers are self-annealing and consequently the quality of the weld is improved.

For upward welding with covered electrodes the fillet must be sufficiently large to allow of such a motion of the electrode tip (weave) that the trailing crater will always

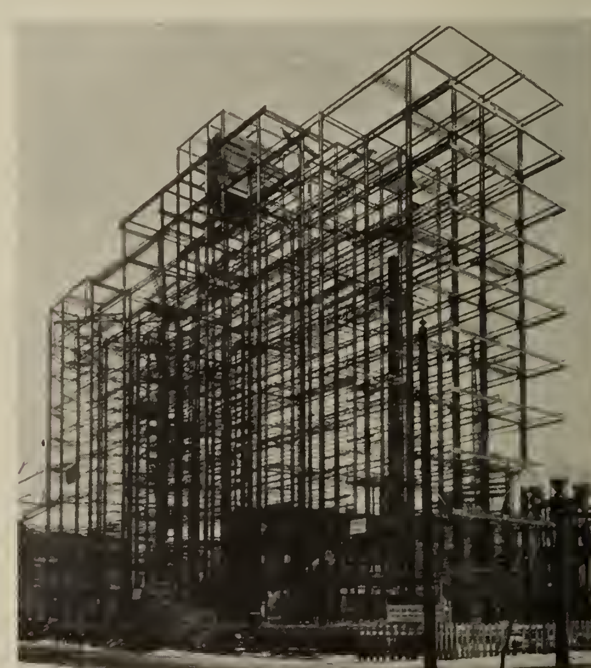

**Fig. 30—All Welded Steel Addition to Western Hospital, Montreal, Designed for Composite Construction.**

be stiff enough to carry the new molten metal above. If the tip of the electrode returns to the crater while it is still very fluid the metal will spill out.

Upward vertical welds can be made with fewer passes than the downward, and the slag is thick and easy to remove. Each layer of downward weld is covered with a thin tough slag which is difficult to remove. The weld made upward is easier to clean and is the one generally used for vertical welding with covered electrodes.

The remarks made above concerning vertical fillet welds are also true for covered rod vertical vee welding.

Practice has shown that a vee rather than a U is better for vertical welding.

### Composite Construction

Arc welding has made possible the development of the Kane System of composite structural steel and concrete construction.

In this system a steel skeleton is designed sufficiently strong to provide for all construction loads including the wet concrete. This steel later functions as reinforcing for the concrete beams of the structure. Relatively small sections may be used because no holes have to be deducted from the cross-section of the parts and minimum dimensions are not limited by the gauges and edge distances required for riveted types of structures. The open web system of the beams provides very convenient openings for duct work and piping. The Western Branch of The Montreal General Hospital was designed and built to this system. (See Fig. 30.)

**Fig. 31—Arc Welded Continuous Deck Plate Girder Bridge at Ste. Anne de la Perade, P.Q.**

### Welded Bridges

Steel bridges of a very pleasing appearance are easily developed by arc welding. In addition to the improved aesthetic effect a very definite saving in steel tonnage is possible.

The bridge at Ste. Anne de la Perade on the Montreal-Quebec highway is a very fine example (see Fig. 31). This whole structure, consisting of several continuous deck plate girder spans with the lower chords shaped to the lines of a flat arch, was shop fabricated entirely by the arc welding method and all field joints and connections were welded.

A saving of 15 per cent was made in the weight of the girders by designing them for continuity; and an additional 15 per cent in weight was saved by fabricating the structure by arc welding instead of riveting.

In connection with arc welded fabrication it is interesting to note that the Canadian Engineering Standards Association is developing a code to standardize the workmanship on arc welded structures by a scheme to qualify shops, supervisors and welding operators in order to develop a uniformly high quality of welded building construction throughout Canada.

### Conclusion

In concluding this article it may be well to repeat what has already been said by many others.

To obtain first class welding it is essential that there be intelligent design, sound shop procedure, adequate supervision, strict inspection by the shop's own inspectors while the work is being done, and a chain of responsibility from the chief engineer to the welding operator.

The future of welding is hard to predict, but if it be judged by the rate of its accelerated development in the last five years, it will embrace an amazingly large proportion of steel structures.

### Acknowledgement

The writer wishes to thank Mr. David Boyd of the Canadian Car and Foundry Company Limited and Mr. Gordon Cape of the Dominion Bridge Company Limited for helpful suggestions and also the companies mentioned in this article for information regarding their welding progress.

# Pre-Cast Concrete Units in Engineering Construction

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—Discusses considerations governing the use of large pre cast construction units, such as caissons, cribs, floor slabs, concrete blocks, piles, tunnel sections and concrete bag work. Methods of transportation and protection against erosion are noted.

During the last five years the author has had occasion, as an officer of The Foundation Company of Canada Limited, to observe the handling of some rather large pre-cast concrete units in connection with a number of engineering works for which that Company held contracts. This refers to numerous pneumatic and open caisson contracts and, in particular, to the Toronto Water Works intake for which Messrs. H.G. Acres and Company, Limited, and Messrs. Gore, Nasmith and Storrie were the consulting engineers, and the reconstruction of berths 1, 2, 3 and 4 at Saint John, N.B., under plans and specifications prepared by Alex. Gray M.E.I.C., as chief engineer of the Saint John Harbour Commission.

In the Toronto operation, sections of pre-cast concrete pipe 8 ft. inside diameter, 9 ft. 8⅜ in. outside diameter and 100 ft. long, were cast in a yard some seven miles from the site of the work. These units, weighing 250 tons each, were towed, while suspended from the booms of a derrick boat, some two miles through Toronto harbour and about five miles through Lake Ontario, placed in a dredged trench and connected together by divers. In all forty-two sections of standard pipe were handled in this manner and, in addition, there were a number of specials.

In the Saint John contract 208 pre-cast concrete caissons were built in the St. John dry dock, and, also suspended from the booms of a derrick boat, were towed across the harbour and deposited in position for sinking. These caissons were 7 ft. inside diameter, 9 ft. outside diameter and varied in length from 55 to 70 ft. and in weight from 110 tons to 140 tons.

Practically all types of caissons, both pneumatic and open, may properly be classed as examples of pre-cast work, inasmuch as they are cast and cured in a position different from that in which they are finally used. They are often transported, by floating or otherwise, considerable distances, and are invariably moved vertically through being sunk to the required depth. The handling of concrete caissons weighing several thousand tons is quite common.

In the preliminary programme of the Semicentennial Meeting of The Engineering Institute of Canada, the subject of this paper is given as "Modern Methods of Precasting Large Construction Units, especially developing the idea that such units can be built better and more economically at a suitable construction yard than in situ." Perhaps the word modern might better have been eliminated as there is nothing particularly new in the use of pre-cast concrete. The use of large concrete blocks in harbour works would appear to have ante-dated our modern Portland cement, and certainly ante-dated modern reinforced concrete construction. Incidentally there is every reason to believe that these comparatively ancient block structures will outlive much of our more modern reinforced work. The term "large construction units" is used advisedly as it is not intended in this paper to deal with pre-cast units of small size.

During some twenty-five years' experience as an officer of a contracting company specializing, among other things, in all types of underwater construction, the author has been greatly impressed with the very decided advantages, in certain classes of work, of pre-casting concrete over pouring it in place, and it has been a source of amazement to him to observe the reluctance on the part of many engineers to adopt the pre-casting method, and the apparent suspicion with which each new proposal for pre-casting is viewed. In this respect Canada undoubtedly lags behind the rest of the world. Pre-cast concrete block work has been used extensively for many years in Europe, but has had a very limited application in Canada, yet it is an exceedingly economical and durable type of construction. Concrete bag work in large units, i.e. weighing upwards of 25 tons each, which might be viewed as a sort of semi-pre-cast system, is virtually unknown here, but in the opinion of the author it could be used with advantage in many cases to form an underwater foundation. It should be an exceptionally safe and economical type of construction in cases where work must of necessity be carried on throughout a long Canadian winter, and where it is necessary to contend with the slow setting of concrete in water that has a temperature only a few degrees above the freezing point. There are many other types of pre-cast construction that suggest themselves to anyone interested in the subject.

It is the intention of the author in this paper to call attention to the advantages of pre-casting and to cite some typical examples of pre-cast work. Wherever possible reference will be confined to structures that have been built in Canada, referring to foreign work only where it has been impossible to find appropriate examples in this country. It may be permissible also to suggest some new applications of the pre-cast system that have occurred to the author in connection with his own practice.

It is evident that the pre-casting system in the form of large units presupposes means of moving the unit into its final position. As might be expected therefore, pre-casting in the past has been largely confined to marine work and railroad work. In the former case the units can be handled on scows or by derrick boats, or can themselves be made floatable. In the latter case derrick cars or wrecking cranes of large capacity can usually be made available. In recent years the crawler crane has been widely introduced and this opens up a vast new field for the further application of pre-casting. The heavy multiple wheeled pneumatic tired trailer and the tractor have made it possible to transport heavy loads great distances with speed and economy, and it is surprising to observe the ease with which equipment of this class can be operated over what may be termed construction roads or, for that matter, over virtually no roads at all.

Transportation, then, is a primary factor and the limiting weight is important. This limit for floatable units is that for which either a dry dock or launchways is available or can be provided. For all practical purposes and in locations likely to be encountered, this imposes practically no real limit on the designing engineer. The pre-cast concrete crib in units weighing from two to four thousand tons is quite generally replacing the older type of timber crib in our deeper harbours, and it appears to have become standard practice in certain of our ports as, for example, Montreal.

For non-floatable units handled by water it is not difficult to rig for loads of 250 tons if the importance of the work warrants it. A scow of canal width and about 125 ft. long can be rigged with shear legs to take about 150 tons.

Our Canadian waters are well served with derrick boats of large capacity which are probably available to all contractors, with the actual owner acting in the capacity of a subcontractor. This at least is the policy of the author's company in respect to its marine plant. As typical of privately owned equipment available for work in the Great Lakes and St. Lawrence and on the Atlantic coast, there may be mentioned the Canadian Dredge and Dock Company's derrick boat *Leland*, capable of lifting and swinging loads of 100 tons, and The Foundation Company's derrick boat *Foundation Scarboro*, capable of lifting and transporting loads of 250 tons. These are believed to be the most powerful vessels of their respective types in Canada. In Halifax harbour there is the Halifax Shipyards' derrick boat *Lord Kitchener*, capable of lifting and swinging loads of 75 tons. In addition there are many dipper dredges that by the removal of the dipper sticks could be readily rigged to handle loads of 100 to 150 tons. Of publicly owned vessels Montreal has a floating crane with a capacity of 75 tons and Quebec one with a capacity of 50 tons, both under the control of the National Harbours Board, and both capable of exceptionally high lifts. There are, at widely scattered points on the Great Lakes, St. Lawrence and on the Atlantic coast, many derrick boats having lifting capacities of about 25 tons. Non-floatable units intended to be transported with the aid of pontoons might weigh anything up to 1,000 tons without requiring anything in the way of extraordinary equipment, and loads up to 300 tons could be handled with scows of very moderate size.


**Fig. 1—Transporting 250-Ton Section of Pipe, Toronto Waterworks Intake.**

Graving docks, floating docks or marine railways, all presumably suitable for the building of pre-cast floatable concrete structures, are located at Port Arthur, Collingwood, Kingston, Montreal, Sorel, Quebec, Port Hawkesbury, Pictou, Sydney, Lunenburg, Halifax, Liverpool and Saint John. In the Lower St. Lawrence and the Bay of Fundy the tides are of sufficient height to permit of the building of many types of both floatable and non-floatable units on almost any convenient tidal flat.

Concrete cribs of large size have been built in pontoons, on ordinary scows and on launchways, and so far as the author is aware, all these methods of building and launching have been uniformly successful. Floatable caissons have in many instances been built on the ice. Non-floatable units within the limit of the lifting capacity of available derrick boats can be built almost anywhere within reach of the water. In general, contractors in Canada are well equipped for this sort of work.

Floatable pre-cast units can be towed any distance in sheltered waters, the length of the tow being only that dictated by economic considerations. It should not be at all difficult to make them seaworthy to permit of their being towed through fairly open water. Non-floatable pre-cast units can be transported on scows under almost any conditions likely to be encountered, the limiting weight being only that for which lifting capacity is available.

The principal use of heavy pre-cast units by the railways would appear to be in the form of girders for short span bridges, and deck slabs for bridges of various types, and large size pipe for culverts. Of bridges of the pre-cast concrete girder type there is a typical example in Montreal in the Atwater Avenue subway of the Canadian Pacific Railway, with a single pre-cast girder and deck slab for each rail on a 36-ft. span, which is believed to be one of the pioneer structures of its type in Canada. The Canadian National Railways have used pre-cast members combining girder and deck slab quite extensively, as for example a slab 3 ft. 9 in. thick and 60 ft. long to carry Cooper's E 60 loading on a clear span of 48 ft. The slab is in two sections, each 7 ft. wide, and each section estimated to weigh 127½ tons. This structure is for a subway on the C.N.R. at Shawinigan Falls (see Fig. 2).

For pre-cast units to be handled overland otherwise than by rail, weights of 15 tons can be handled without anything in the way of extraordinary equipment. Weights of from 25 to 40 tons can be placed with two crawler cranes of moderate capacity. The record for overland transportation by trailer, so far as the author is aware, is a 12-ft. 8-in. inside diameter pipe line forming part of the Colorado River aqueduct, pre-cast in a central yard in sections 12 ft. long, weighing 43 tons each, and distributed over some ten miles of line. In all this project involved approximately 46 miles of large pre-cast pipe varying from 9 ft. 8 in. to 12 ft. 8 in. inside diameter.

Many of the advantages of pre-casting are obvious and are applicable to a wide range of structures. Other of the advantages are principally applicable to special types of structures. In still other cases the primary advantage of pre-casting is one of erection, as, for example, a bridge slab that can be placed in a railroad track that is carrying traffic under conditions that would absolutely preclude the use of a cast-in-place structure.

Of advantages of the first class, that is of general application, perhaps the most important is the fact that concrete mixed and poured in a well designed central plant is as a rule of superior quality. The proportioning, mixing, placing and curing are all done under the most favourable conditions. Practically every mechanical aid to good results can be utilized and efficient inspection of each operation is assured. Of primary importance also is the fact that the cost is reduced, and as a rule this reduction applies not only to the labour employed in handling materials, mixing and placing, but also to such items as power, plant depreciation and maintenance and repairs. Perhaps the greatest reduction in cost that can be effected in any single item is that applicable to forms. The cost of these in the case of pre-cast work is likely to be less even if only one or two similar units are built. If any considerable number of units is to be built the operation can be organized on a mass production basis and the cost of forms is reduced to a small fraction of the cost of this item in poured in place work.

In pre-cast work the mixing plant and casting yard can be located in a place that is convenient for the economical delivery of materials, and that offers facilities for the storage of reasonably large quantities of cement, sand and coarse aggregate and of finished units. The operations of setting up and stripping forms and of placing the concrete do not interfere with other operations, as in the case of casting in place, and are not themselves interfered with by operations that must of necessity be performed at the site of the work itself. A great deal of confusion and lost motion is inevitably eliminated. The cost of transporting a given tonnage in the form of completed units from a well located casting yard to the work is likely to be less than the transportation of the same tonnage of separate ingredients from the point of delivery to a mixer on the work, and of the same materials plus excess water from the mixer to the forms. Given appropriate conditions then, pre-cast work furnishes a superior product at a lower cost and, in addition, provides for more orderly operation with every prospect of being able to carry it out on a much faster schedule.

Of advantages applicable to special work by far the most marked are those applying to marine work, using the term in its widest sense as including work on, over or under the water, or that may be exposed to water. Here the superior quality of pre-cast concrete is of particular value. The finished work is subjected to severe exposure and to factors that tend generally to limit its life. Unquestionably pre-cast concrete, made and cured under ideal conditions, is much better able to resist these extreme conditions. The most dangerous exposure of all would appear to be that portion of a structure in sea water that is within the tidal range. Here concrete at its best has not had a particularly good record in climates with low winter temperatures such as exist in Canada, and under these conditions it seems open to question whether concrete is in any sense the durable material that the public generally has been led to believe. There can be no doubt as to the necessity for work of better quality than much of the work that has been done in the past. It is incumbent upon engineers and contractors, and upon all commercial organizations interested in the promotion of the use of concrete, to improve their methods and improve the quality of their product.

For all such work that is within the tidal range the author would strongly recommend pre-casting with proper curing. If in the position of being the engineer in responsible charge he would go further than this and would bar absolutely the use of cast-in-place concrete in the tidal range in Canadian waters for any structure where durability was an important consideration. Poured in place

Fig. 2—Preparing to place Pre-Cast Bridge Slab. Canadian National Railways.

concrete might be used inside a tight coffer-dam if the conditions were such that it could be properly cured, but even then pre-casting is preferable.

Perhaps it might not be out of place here to say a few words about protecting the surfaces of concrete that is in water and exposed to alternate freezing and thawing. The author is of the opinion that this should be done wherever possible, and generally it is both possible and practicable. There are bridge piers within the tidal range of the Bay of Fundy, perhaps the most severe exposure that could be found, so protected, that have proved wonderfully durable. Other concrete exists in the same general locality, not so protected, and presumably built under a rigid specification, that might fairly be classed as among the most perishable of construction materials. The author has seen one of several piers in a bridge where the concrete has been protected by timber cribwork, erode to what amounted to virtual destruction in an unbelievably short time, due to a single timber having been forced out of place by ice. The more the author sees of concrete in water the more convinced he is of the advisability of this protection, even in fresh water between the high and low water marks. For some reason concrete seems to have a relatively hard and durable surface skin and to be relatively perishable once this skin is removed by erosion or by alternate freezing and thawing while wet. This is seen in harbour works, in the spillways of dams and in bridge piers.

In fresh water as, for example, the Great Lakes and Upper St. Lawrence, steel sheet piling has proved to be a most effective form of surface protection. It is cheaper than steel plate, can usually be fabricated in the field, and the excess metal in the interlocks is of great value in resisting shocks from floating ice and from logs. The designer can often arrange it in a manner that gives a pleasing appearance. Wood is an efficient protection but unless continuously submerged it should be creosoted. In sea water the timber must be creosoted in locations where wood borers are likely to be found. Protecting concrete with wood simply means that the forms are made so that they are a part of the finished structure, and they should therefore be made of thicker material than would otherwise be used, and should be well anchored with galvanized fastenings. The author believes that brick, either vitrified or semi-vitrified, has been used as a concrete facing material in Europe but he knows of no case of its having been used in Canada as a protection against alternate freezing and thawing and would hesitate to recommend it, fearing that the mortar joints would be attacked. He knows of no case of chrome nickel iron, i.e. the so-called stainless steel, having been used for protecting concrete, but in his opinion this might have great merit. It would be expensive, but probably not so expensive as granite, and certainly not so expensive as rebuilding a costly concrete structure after a comparatively few years' service. Copper might be given consideration as a protective surfacing. Cast iron in the form of ribbed panels of suitable size should be very effective.

Reference has been made above to the advantage of pre-casting marine structures from the standpoint of obtaining concrete of a more durable character, and from the standpoint of the lower cost of forms and of mixing, placing and curing. The subject may be considered from the standpoint of another item of considerable cost. The saving through the elimination of cofferdamming and pumping is often tremendous. It requires little imagination and no figuring to reach the conclusion that a cast-in-place structure to replace the concrete cribs of the type commonly used in Montreal would be financially impracticable. Yet there has been little or no attempt in Canada to apply this principle of a floatable watertight concrete box to other structures in the water, such as, for example, bridge piers, pump houses, lighthouses and the like. The caissons of these structures have been floated to the site but there seems to be an unwillingness to use caissons except where it is deemed necessary to reach a depth impracticable with a cofferdam. One can visualize a hollow bridge pier built complete in a dry dock except for the centre filling, and floated to the site and sunk on a prepared foundation. One can visualize another type of pier in which the foundation would be two or more cylindrical caissons sunk through wells in the floatable pre-cast portion. This would give a very strong pier with the caissons acting somewhat like the roots of a tooth.

The caisson is a type of pre-cast work in which the author has been particularly interested for about twenty-five years. His remarks on this subject may lead to an accusation of being a propagandist on behalf of the company with which he is associated, but he must take that risk. As a means of providing a foundation in water that must be carried to even moderate depth, the caisson, pneumatic or open as the occasion demands, offers an absolutely sure and safe solution. This is said after due consideration, in the belief that the engineer who builds on a properly designed caisson foundation may rest assured that he will have no settlement of his structure that will reflect upon his professional reputation. There seem to be two beliefs in regard to caisson work that are quite widely held even in the professional mind, and that seem quite erroneous. The first is that caisson work is expensive, and the second is that a caisson must, if it is physically possible, be carried to rock. Unfortunately the second statement is often accepted as axiomatic and the first statement thereby becomes a fact. Where the depth exceeds say 35 ft. the caisson is likely to be an economical solution of the foundation problem, though this point of economic depth must vary somewhat with the conditions of each particular case. If a bridge caisson, for example, is carried say thirty feet into the ground, or that depth below any point of possible scour, it is the author's conviction that it can there be founded on any reasonably hard stratum with perfect safety, provided no extraordinary conditions exist. There is no necessity for carrying it to rock. This statement should be modified in the case of a bridge of unusually long span or in the case of an exceptionally soft clay or light silt overburden. If the caisson is of the dredging type and is carried about thirty feet through material that will give a reasonable amount of lateral support, it will usually be sufficient, for loads of anything up to 12 tons per square foot, to found it on any fairly thick stratum that is sufficiently hard to prevent dredging further with the ordinary heavy bucket. Unless the span be exceptionally long the load under a bridge pier seldom reaches 12 tons per square foot.

A caisson, like a pile, is unique in the fact that it gives, to one who can read the signs, an accurate indication of its carrying capacity as it is being sunk. Just as an experienced pile man can tell what a pile will carry by the way it drives, so an experienced caisson man can tell by the way the caisson acts where and how it must be founded to carry a given load. In all the author's experience he can recall only two cases of bridges of moderate span where the caissons could not with perfect safety have been founded at depths of less than forty feet. The interest on the money he has wasted in carrying caissons to quite unnecessary depths would place him among the fortunate beings who have moved to those places where income taxes are of secondary importance.

There is one more characteristic of the caisson that might be noted, and that is its ability to resist eccentric loading. Again barring extraordinary conditions, the effects of the usual lateral forces and of even quite large eccentricities can be completely ignored in the case of the caisson, as the opposing passive resistance of the soil is sufficient to overcome this if the caisson is carried even a moderate depth into the ground. Were this statement not correct our wood pole transmission lines would hardly withstand anything more than a comparatively gentle breeze. It is quite common to find specifications requiring extraordinary and quite unnecessary accuracy in the sinking of caissons, thereby forcing contractors to include in their estimates comparatively large sums for special rigging and guide frames which they know will be demanded to meet the specified requirements. Occasionally one sees a specification stating that a caisson must be sunk to exact position, a requirement that it is obviously impossible to fulfil, but one that is certain to add considerably to the cost of carrying out the work. The designer, if he be skilled at his trade, will know and anticipate the probable drift of a caisson and determine its size accordingly, and specify in exact figures what top and bottom drift has been allowed for in the design. Such a caisson will probably be built and sunk for less money than one that is designed too small in the first instance through lack of allowance for drift, and which requires extraordinary accuracy in sinking to make up for this deficiency. In the opinion of the author, the economical design of a bridge pier caisson in say 30 ft. of water and to be sunk say 30 ft. into the bottom, would have a margin around the base of the pier shaft of not less than 30 in. if sunk by the pneumatic method, or of 42 in. if sunk by open dredging. There would probably be no necessity for carrying this caisson to rock and a lot of needless expense would thereby be avoided, bearing in mind that the cost of excavation in the upper strata may be only a few dollars per yard, whereas the cost of carrying it through a perfectly good hard stratum at a depth suitable for founding, may easily exceed one hundred dollars per cubic yard.

Apropos of the allowable drift of bridge caissons the author, some years ago, with the concurrence of the chief engineer of one of our principal railways, had the opportunity of conducting an interesting full scale experiment. A number of similar piers were to be founded on dredging caissons sunk through a rather soft soil to a depth of about 60 ft. As he recalls, two of these caissons were of what might be termed standard design, with a minimum allowance for drift. Two caissons were made substantially larger, one with the extraordinary allowance of some five feet between the pier shaft and the sheeting of the caisson. It is no exaggeration to say that the sinking of this caisson measured in days took less time than one would ordinarily figure in weeks, and that the cost was unbelievably low.

The principal use of caissons in Canada has been in connection with bridge piers, and for this work two types have been used, the pneumatic and the open dredging. The term "caisson" is here used in its restricted sense to designate a vertical shaft with a horizontal cross section of whatever size and shape is required. The characteristic feature is that it is built to a certain height and is then sunk into the ground by excavating from the interior. The primary function of the caisson is to permit of an excavation being carried through a water bearing soil. As originally used, it often served only this purpose and the caisson proper, on the American continent at least, was generally built of wood with a pier of brick or stone built inside of it. With the introduction of concrete the caisson became the pier itself and took the form of a concrete shaft, with or without permanent outside forms of wood or metal.

The pneumatic caisson has a cup-shaped depression in the bottom called a working chamber, terminating in a rather sharp rim called a cutting edge. The working chamber is connected with the surface by two or more shafts used for getting men into and out of the working chamber and disposing of the excavated material. The water is kept out of the working chamber by compressed air, and to maintain this pressure the shafts are fitted with air locks. The open caisson has the cutting edge but has no working chamber. The shafts are larger and the excavating is done with a clamshell bucket working through them. If there is not too much water the excavation in an open caisson may be done by hand in the dry, the water being held by pumping, but generally the excavation is in the wet and no attempt is made to exclude the water. It frequently happens that a combination caisson is used, that is, one that is commenced as an open caisson and bottomed under the pneumatic process, a deck or a concrete plug being formed in the large dredging shafts to effect the conversion.

If the caisson be for example for a bridge pier, the working chamber in the case of the pneumatic process is completely filled with concrete. Usually the shafts also are specified to be filled but there does not appear to be any reason for this unless the conditions are such that the water inside the shafts might freeze, a condition seldom met with in practice. In the case of the open caisson the bottom is sealed with concrete placed under water, and the shafts also are often filled with concrete. Unless the conditions of loading be quite extraordinary it is difficult to find any logical reason for concreting the shafts, as a sub-base at or immediately below the water level will spread the load to the caisson walls and will eliminate any possibility of freezing. If weight be required, the excavated material is almost as efficient as concrete for filling, but inasmuch as the effects of lateral forces and eccentricity seldom reach the cutting edge, it is the exceptional case where extra weight is required or is desirable.

Pneumatic caissons are commonly used for building foundations in lower New York where the rock is from 50 to 100 ft. below street level and is overlain by quicksand. There are a few places outside New York, including Montreal, where buildings have pneumatic caisson foundations but unless the character of our buildings changes radically there is little justification for this type of foundation in Canada. The economic minimum size for a pneumatic caisson is about six feet and this, if carried to rock, can take a safe load of about 700 tons. It is seldom that in Canada there is a building tall or heavy enough to produce this concentration, and such a caisson is likely to be loaded to only about half its capacity. The concrete pile and the steel pile would appear to be a more economical solution.

Caissons may be used for another purpose than that of forming a foundation, i.e. for constructing a shaft through water-bearing soil. The soft ground portions of mine shafts are typical examples. Here the caisson has a large shaft that is not filled. If the pneumatic process is used a temporary deck is built in the shaft to form a working chamber. The bottom seal takes the form of an annular ring of concrete (see Fig. 3).

In Europe the pneumatic caisson has been used quite extensively in the construction of quay walls in harbour works, but so far as the author is aware there are only two instances of this application in Canada. At the Windmill Point wharf and at Alexandra pier, both in Montreal, walls have recently been built in front of the old cribwork by the pneumatic process to permit of dredging to a greater depth. At Windmill Point the caissons were 90 ft. long by 5 ft. 4 in. wide, sunk end to end to form a continuous wall. At Alexandra pier a continuous line of caissons 7 ft. in diameter was used. In both cases the new wall had to be carried some distance into the rock.

Caisson work, particularly by the pneumatic process, can be done today at a cost far below that of twenty-five years ago, in spite of the increase in the cost of both labour and materials. During the period between 1912 and 1914 the company with which the author is associated cut its costs on certain types of dredging caissons by about 30 per cent through improvement in design and in methods, and successfully adapted the open dredging caisson to conditions that had previously required compressed air, thus effecting a further reduction in cost. The modern types of air compressors introduced during the last five years have contributed to a substantial reduction in the cost of pneumatic work, and the same may be said of the recently adopted welded steel working chamber.

Perhaps a few remarks relative to the types of caissons to meet various conditions may not be out of place. A circular caisson is cheaper than a rectangular one, and the more closely the latter approaches a square the cheaper it will be. The minimum economic size for a circular dredging caisson would appear to be about 6 ft. inside diameter and of a pneumatic caisson about 6 ft. outside diameter, although these limits will vary somewhat with the depth and the character of the soil. The minimum for square caissons should be about the same. A rectangular caisson with a great ratio of length to width is decidedly expensive, and this ratio should preferably not exceed about seven to one. Assuming the minimum economic width to be 6 ft., the maximum economic length would be about 40 ft. In a dredging caisson the minimum thickness of the outside walls might be about 12 in. for small caissons and 30 in. for large caissons, and the maximum about 72 in.

A dredging caisson is well adapted to conditions where the soil is fairly soft or is of a sandy or gravelly nature

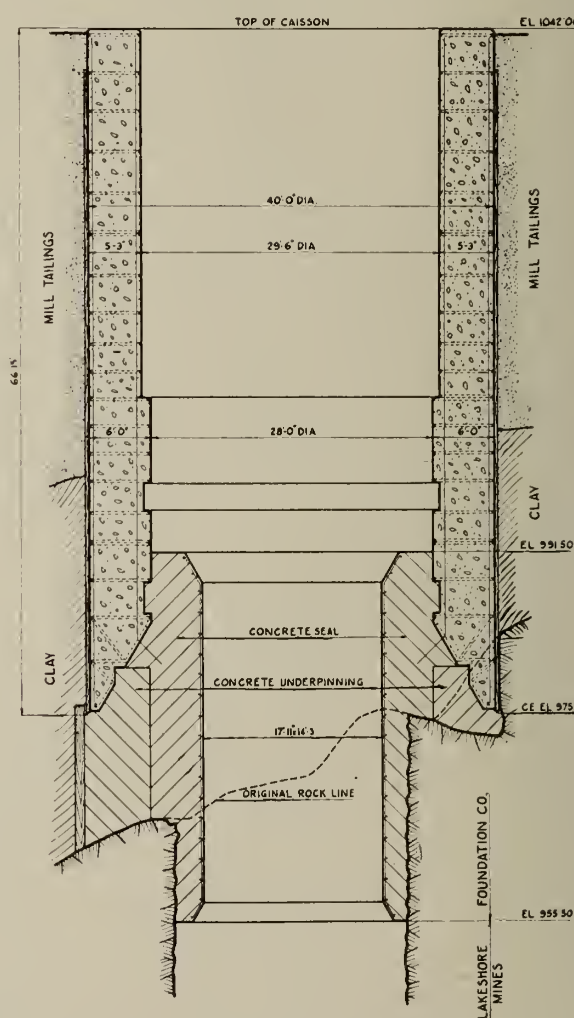


**Fig. 3—Pneumatic Caisson for Shaft, Lake Shore Mines.**

for a considerable depth, and where the foundation is not to be carried to rock. It is likely to be expensive if it has to be sunk through any considerable mass of large boulders and the cost may be prohibitive if it has to be carried through hardpan. Other than in a mine shaft or similar structure the conditions would seldom be such that an economic design would contemplate carrying a dredging caisson to rock. Should the rock be uneven this type of foundation may be found to be quite impracticable. The pneumatic caisson should be used where the load is such that the foundation must be carried to rock or any distance into rock, and particularly where the rock level is likely to vary more than about 3 ft. in the area covered by the caisson. A dredging caisson is not suitable for use close to and below an existing structure as it usually causes a subsidence of the ground around it.

**Fig. 4—Method of Launching Caisson at Halifax.**

It is believed that floatable concrete cribs of the modern type were first used in Canada on the Welland canal. They have since been used extensively in Montreal and were used in three wharves in Halifax. They are generally rectangular with interior longitudinal and cross walls dividing them into a number of rectangular cells. A portion of Windmill Point wharf is faced with cribs of slightly different design with the principal cells circular in plan. The standard crib as used in Montreal harbour is rectangular, 112 ft. long by 42 ft. wide by 42 ft. high. It contains 1,681 cu. yd. of concrete, 195,800 lb. of reinforcing and weighs complete about 3,600 tons. The launching weight is about one third of this.

Various methods of building and launching these cribs have been employed. One patented method used a floating pontoon, the bottom and sides of which served as forms for the bottom slab and the lower portion of the side walls. Another system used a pontoon consisting of a rectangular box somewhat larger than the finished crib, which was removed by lowering weights on to the four corners and sinking it until the crib could be floated free. Concrete cribs have been built on the decks of scows and launched by letting sufficient water into the scow to give it the required list. Many of the cribs used in Montreal were built by the Atlas Construction Company Limited in a graving dock on the Lachine canal, which is obviously an excellent method where a suitable dock is available. On a number of recent contracts in Halifax and Montreal the cribs were built and launched from ways. In an ingenious system used by E. G. M. Cape and Company in Halifax, and recently in Montreal, the crib is built on a level platform which can be tilted on its longitudinal axis to an angle corresponding with the slope of the standing ways which the platform engages when the required degree of tilt is reached (see Fig. 4).

These cribs are usually founded on a rubble mound topped off and levelled with finer stone. They are sunk in the required position and filled with selected material which is rock if available, otherwise any material of a gravelly or sandy nature. So far they have proved to be a successful and economical type of construction, but the author feels that there must still be a good deal of doubt as to their durability in salt water. To make them floatable the walls must be relatively thin, leaving the reinforcing rather vulnerable to attack, and once corrosion of the bars commences the effective destruction of the thin walls would seem likely to progress quite rapidly.

Structures similar to our concrete cribs have been used for many years in European harbour works, but their practice seems to have been to use much thicker walls and more substantial construction generally. This may be the result of a broader experience on the part of European engineers with masonry construction for quay walls and the like, and it is possible that we may have cause to regret the use of very thin walls in some of our structures.

The concrete crib seems to have been adapted in Canada to wharf work only, either in the form of a bulkhead or a pier. As stated earlier in this paper, there is no reason why the same principle should not be applied to bridge piers with pneumatic caissons sunk through certain of the cells, or with the base resting on piles cut off to the required level. An alternative arrangement might be to form a base of concrete deposited under water and screeded to a level surface, and on this found the floatable pre-cast section of the shaft that would carry the work above the water level. This was the method used in forming the foundation for the large pre-cast three way distributor for the Toronto Waterworks Intake (see Fig. 5).

Mr. Joseph J. Yates, bridge engineer of the Central Railroad of New Jersey, has kindly furnished the following

**Fig. 5—Three-Way Pre-Cast Distributor, Toronto Waterworks Intake.**

data of a remarkable bridge in which advantage was taken of the saving in time and in cost due to pre-casting the bases and the sidewalls of the sub-bases of the double track piers. The bridge is a four-track structure consisting of two double-track bridges side by side, each with a length of 7,411 ft. crossing the open water of Newark Bay. It is an important structure carrying some 300 scheduled passenger trains a day, in addition to the railroad's freight business, to its New York terminal. It is said, with its approaches and grade crossing eliminations, to have cost about $15,000,000. It consists of 41 main plate girder spans, twin vertical lift spans with flanking truss spans, and an approach viaduct. The lift spans are founded on pneumatic caissons. The other main spans, which are of present interest, were founded on timber piles driven in a dredged trench and cut off level. On each of these pile groups there was landed a floatable cofferdam, the bottom of which formed the base of the finished pier surmounted by a cellular structure cast integral with the base which formed the walls of the sub-base. On this was bolted a removable cofferdam in which the pier shaft was built (see Fig. 6). Some of these cofferdams were used as many as twelve times, indicating a remarkably efficient operation. The caissons were built and launched from ways in the usual manner.

Where the depth of water permits, there appears to be no reason why the scheme used on the Newark Bay bridge could not be carried still further in so far as the pre-casting is concerned. The cellular sub-base walls might be carried up to within a few feet of water level and the shaft proper commenced at this level. This would reduce the timber cofferdam to a very small affair.

Concrete block work might have a much wider application for marine construction in Canada than it has had in the past. It has been quite widely used on the Great Lakes for that narrow band between the high and low water marks, and with excellent results. Here poured in place concrete is not appropriate, as "honey-combing" at the water line seems to be the inevitable result, and the life of such concrete is often exceedingly short. Repairs to this narrow strip at the water line can be made with "gunite" during a period of exceptionally low water, but a structure carelessly built and subsequently patched is never so good as one well built in the first instance. Concrete blocks when used in the manner described are usually founded on a timber crib or on some kind of a platform carried on piles. They are usually surmounted by a copewall of poured-in-place concrete. It is suggested that this latter might also, with advantage, be made of pre-cast blocks with only a shallow band of cast-in-place concrete forming a curb at the top of the wall. With this construction it would be possible at moderate expense to take down the whole or any part of a wall when the course of blocks at the water line has lived its useful life, and rebuild it, using the upper course of blocks at the water line and the damaged blocks for the top course, with the eroded faces turned toward the back of the wall. If necessary any damaged blocks could be made good at this time with "gunite." In this type of construction it appears that a decided improvement could be effected by protecting the exposed face of the bottom course of blocks with wood or metal well anchored to the concrete.

In all such block work, the author believes, the individual blocks should be made as large as possible, the weight being limited only by the lifting capacity of available equipment. The cost of forms per cubic yard for large blocks will be less than the cost for small blocks, and the cost of placing a block weighing 25 tons will not differ greatly from the cost of placing one of 5 or 10 tons. Fewer joints will result from the use of large blocks, and in all masonry work the joints are particularly vulnerable to attack by the elements. If sufficiently large blocks are used, dowelling becomes unnecessary and can be eliminated. For small work it is suggested that blocks of 20 to 25 tons each might be appropriate, while for work of any considerable magnitude blocks of from 50 to 100 tons each would not be out of the way.

There would appear to be no great advantage in making pre-cast blocks hollow or cup-shaped as is sometimes done, and afterwards filling them with poured in place concrete. The saving to be made by using a leaner mix in the filling will probably be less than the extra cost of forms and the loss through having two separate operations where one would suffice. About the only factor that may be suggested in favour of the hollow block filled afterwards is that with equipment of given capacity it results in fewer joints per unit of face. Where the filling material can be rock, or where the conditions are such that no filling is necessary, the hollow block is obviously advantageous.

In the horizontal underwater joints of block work the author would propose the use of wood from ½ to 1¼ in. thick, creosoted if marine borers are present. This could serve as the bottom form when casting. Other suitable types of jointing material that suggest themselves are asbestos in combination with a suitable bituminous compound, which could be made in sheet form and cast on the bottom of the block. Vertical joints below water can, if necessary, be caulked with lead wool and grouted, but this would be required only under some extraordinary conditions. Generally speaking they can be left open. An inexpensive method of closing vertical joints at or immediately below the water line is to fill them with a continuous line of well driven wooden wedges.

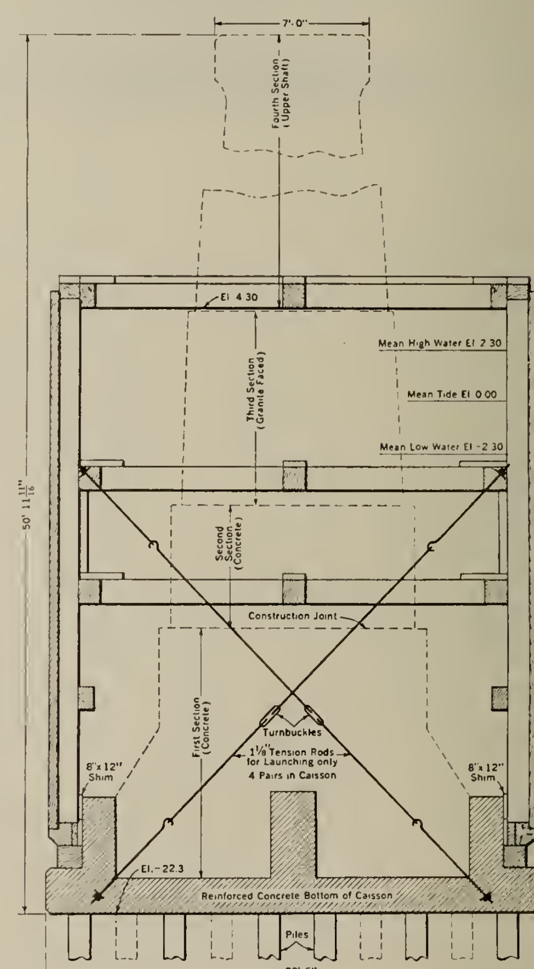


**Fig. 6—Section Through Concrete-Bottomed Cofferdam for Piers of Newark Bay Bridge. Jersey Central Railroad.**

Undoubtedly the most effective use of concrete blocks in Canada is in the Great Lakes wharves to which reference has already been made. There are some examples of this in Montreal harbour and there is every indication that where this system was used there is much less erosion at the water line than where mass concrete was used. The largest project in which pre-cast blocks were used is the Ocean Terminals at Halifax. Here the quay walls, founded at depths of from 30 to 40 ft. below water, were built of cellular concrete blocks illustrated in Fig. 7. An article in The Engineering Journal for October, 1918, gives the size of these blocks as 21 ft. 10 in. on face, 31 ft. from back to front, and 4 ft. 1½ in. high, and the weight 62½ tons. They have 8 in. reinforced walls and interior walls dividing

Fig. 7—Block Casting Yard, Ocean Terminals, Halifax.

the block into twelve cells. They were founded in part of the work on a rock foundation, and in the deeper parts on a rubble mound. The face cells and those in the centre of each block from front to back were filled with concrete. The remaining cells were filled with rock.

It is worth noting that the most recent addition to the ocean terminals at Halifax, the fish landing pier, is of concrete crib construction which has been largely developed since the original piers were built. Doubtless if the whole project were being built today, floatable cribs would be given serious consideration in place of the hollow block construction.

Before leaving the subject of pre-cast work in water one must not overlook the concrete pile, but it is to be feared that owing to its comparatively high ratio of exposed surface to cross-sectional area, it is not suitable for use in water in our Canadian climate unless some really effective and inexpensive method of surface protection is devised. Pre-cast piles about 8 in. in diameter have been used in the tropics with the knowledge that in a few years they will be ten or twelve inches in diameter due to a deposit of mollusks that seems to form a surface coating that is possibly more resistant than the concrete itself. In an eastern Canadian climate the reverse occurs, the alternate freezing and thawing resulting in a surface disintegration that quickly destroys a member of such small cross section, and particularly one that must be reinforced with the bars rather close to the surface. A pile 30 in. in diameter would be considered a large pile. A surface erosion of 4½ in. would cut its area in half and probably eliminate the entire effect of the longitudinal reinforcing. If the pile is 18 in. diameter an erosion of 2⅝ in. will cut its area in half.

It is rather expensive to protect the surface of concrete piles at the water level. If creosoted timber is used it should presumably be very well fastened with copper or bronze bands. It would be interesting to test the effectiveness of a stainless steel or copper protective covering on a concrete pile between high and low water, but this might be commercially impracticable on account of the high cost per ton of carrying capacity of the pile. For example, an 18-in. pile carrying 50 tons would require 13.6 sq. in. of protection per ton capacity per lineal foot covered, whereas the caissons used at Saint John would require only 2.66 sq. in. of protection per ton per lineal foot if carried to rock, or 5.33 sq. in. if founded on hardpan.

For use in the dry, the cast-in-place concrete pile would appear to be superior from practically every standpoint to the pre-cast pile, and it is at the same time less expensive. In general the pre-cast concrete pile in water would seem to be inappropriate to our eastern waters and more costly per ton capacity than other much more suitable types of foundation. On the Pacific one would hardly expect the concrete pile to compete with timber.

There are few examples of pre-cast concrete pile construction in Canada. The most important is Pier No. 2 at Halifax, a structure 800 ft. long by 235 ft. wide, in water from 34 to 57 ft. deep. The piles are 24 in. square in cross section and in length vary from 47 to 77 ft. The heaviest would probably weigh about 25 tons. The materials through which the piles were driven are stated to have consisted of from 5 to 27 ft. of soft mud and 2 to 12 ft. of hard clay and gravel overlying the rock. Lateral stability is secured by means of batter piles which have apparently proved quite adequate in spite of the very shallow penetration of the piles in anything other than soft mud. It is interesting to note that the piles were protected with 4 in. of creosoted timber between high and low water. While some repairs have had to be made to this structure, it may fairly be said that this sheeting has been on the whole effective.

The small cylindrical caisson is, in effect, a large pile, and in wharf work serves the same purpose as the pre-cast concrete pile. Unless the loads be very light, it is superior to the pile in every way. Having less exposed surface per ton carrying capacity it is more durable and is easier to protect from the elements. If the outside forms are made of wood well fastened with galvanized bolts to interior angle rings, these in themselves offer excellent surface protection. Steel plate at the water line is an efficient form of protection but it should be of some rust resisting alloy.

Unlike the large concrete pile, cylinder construction does not require expensive special equipment. An 8-ft. diameter cylinder weighs about 1½ tons per lineal foot, permitting a 25-ton crane to handle it in 16-ft. lengths. If larger equipment is available there is an advantage in having fewer joints. A strong scow about 125 ft. long can be rigged with shear legs that would permit of the ordinary sized cylinder being handled in a single section long enough

Fig. 8—Work in Progress, Berth 3, Saint John, N.B.

to reach from the bottom to well above the surface of the water.

The cylinder is sunk to a hard bottom by dredging, or it may be sunk as a pneumatic caisson. If it is to be founded above the rock level, the open dredging process is quicker and cheaper and equally effective. If it is to be sunk through a hardpan or boulder formation or into the rock, the pneumatic process should be specified. If the pneumatic cylinder is founded on hardpan an enlarged base can be formed. Without extraordinary expense, the diameter of this can be about 2 ft. 6 in. larger than the cylinder. A pneumatic cylinder 6 ft. in diameter belled out on hardpan can carry about 650 tons, or if carried to rock about 700 tons. There is therefore little incentive to carry it to rock if hardpan is available. An 8-ft. diameter dredged cylinder will carry about 600 tons.

**Fig. 9—Transporting Caisson from Drydock to Site, Saint John.**

As an alternative to carrying cylinders to the depth necessary to secure a suitable foundation, they may be carried to a depth sufficient to give the required stability, and steel piles may be driven inside them to the necessary bearing and a concrete plug poured to transfer the load from the cylinder walls to the piles. The author does not favour wood or pre-cast concrete piles in cylinders, as it is doubtful if enough of them could be driven in the comparatively small space available to develop the strength of the cylinder walls.

There are two outstanding examples of pre-cast cylinder work in wharf construction in Canada, the Ballantyne pier in Vancouver, built under plans of Mr. A. D. Swan by the Northern Construction Company, and Berths 1, 2, 3 and 4 at West Saint John, N.B., to which reference has already been made. The pneumatic cylinders used to face Alexandra pier and the open cylinders used at King Edward pier, both in Montreal, were cast in place.

Bag work has been described as a sort of semi-precasting system, one which, so far as the author knows, has not been used in this country. The term does not refer to cement bags holding some fraction of a cubic foot, but to large bags holding several cubic yards. These would be of canvas or jute, strongly made and of a size to fit quite loosely into a special bottom dump bucket somewhat similar to the bucket commonly used to deposit concrete under water. The method of operation would be first to place the bag in the empty bucket, then fill it with the required batch of concrete and close the top by sewing or lacing. The bucket would then be lowered to the bottom and gently discharged in the required position. In this manner a concrete foundation could be built under water in even a swift current without danger of segregation or of loss of cement, and without the formation of laitance. There will be no mechanical bond between the separate bags but they will conform closely to whatever surface they are placed on, and if sufficiently large will offer great resistance to lateral displacement. The author sees no reason why bags of this character should not be made to hold say 20 tons of concrete each, and can conceive of many cases where this type of construction would be particularly appropriate.

Pre-cast concrete pipe is so widely used that any description is superfluous, and it would seem sufficient to note some of the outstanding projects from the standpoint of size and weight of units handled. It is believed that the largest units handled in any considerable number by derrick boat were the 100 ft. sections of pipe for the Toronto intake, weighing 250 tons each, as shown in Fig. 1, although without doubt larger single units have been tackled. These were pre-cast on skidways and hauled by tackle to the water's edge within reach of the derrick boat. The operation was very successful. The heaviest sections of pipe handled overland were the 43 ton units on the Colorado River aqueduct (see Fig. 10). Concrete pipe of moderate size is now turned out on a mass production basis and it seems likely that this will supersede steel and cast iron in our future submerged pipe lines for anything in excess of about 24 in. in diameter. The intakes themselves and the specials can be conveniently built up in "gunite" or a combination of pre-cast concrete and "gunite."

From time to time tunnels have been built by dredging a trench across a river bed and depositing in this tubular sections, as was done, for example, in the Detroit-Windsor tunnel. Here the tubes were of steel plate construction encased in concrete poured through a tremie. In the Oakland-Alameda Highway tunnel in California the river section was made up of pre-cast concrete units 203 ft. long by 38 ft. outside diameter, with walls 3 ft. thick. Twelve of these sections were pre-cast in a dry dock, three at a time, fitted with end bulkheads and towed to the site and sunk in place (see Fig. 11). The weight of each unit was about 5,000 tons and its draft while floating about 25 ft. The system was completely successful and is doubtless much cheaper than any form of metal tube encased in poured in place concrete.

**Fig. 10—Unloading 43-Ton Section of Pipe, Colorado River Aqueduct.**

This discussion as applied to marine work has so far dealt with construction that is actually in the water. There is still another class of work to consider, that is, those parts of a structure that are over the water as, for example, the decks of wharves, the girders and decks of concrete bridges, etc. Here all of the previous arguments apply, some to a lesser and some to a greater extent. When dealing with salt water, the degree of exposure is admittedly less but is still sufficiently severe to demand the dense, impervious concrete that can more readily be produced in a central casting yard. The saving in the cost of forms is likely to be much greater than in almost any other class of structure,

**Fig. 11—Towing Pre-Cast Tunnel Section to Site, Alameda Tunnel.**

as when working over the water these must be as a rule supported on piles or the spans must be made long enough to use the finished substructure as the medium of support. In either event both the erecting and the stripping become exceedingly costly. If the work is of any magnitude a great deal of time and expense incidental to the erecting and stripping of forms is eliminated by pre-casting.

In decks and slabs one frequently hears the argument that in a pre-cast structure the effect of continuity is sacrificed. This argument seems much more theoretical than practical. If, as is frequently the case, the foundation is on timber piles, it is doubtful if the bearing value of the foundation, taken as a whole, is sufficiently uniform to give the complete benefit of continuity, and it would appear that to attain this one must almost have a foundation that is entirely on rock or on some comparatively unyielding and uniform stratum that is fairly deep and is not likely to suffer any disturbance during the life of the structure. If, to get the saving due to continuity, comparatively large areas are poured as a continuous operation, it seems reasonable to suppose that the shrinkage stresses go a long way in upsetting the theoretical calculations. If, as is generally specified, joints are made at the point of maximum bending moment, it again seems doubtful if the full effect of continuity is realized. One has only to observe the tendency of these joints to open up in the form of hair cracks to realize that the shrinkage stresses have completely cancelled the dead load compressive stresses. In pre-cast work the cumulative effects of shrinkage are entirely eliminated, and if conditions warrant it, continuity can be obtained in the principal members by connecting the negative rods together over the supports and pre-stressing them if considered desirable. Some sort of a yoke that will be operative with a reasonable amount of lateral displacement would appear to be the logical form of connection.

Before closing it would seem appropriate to refer to two rather remarkable instances of the use of pre-cast concrete. Both of these were what might properly be called "stunts" and as such have already received wide publicity. This reference is to the large open caissons for the Little Belt bridge of the Danish State Railways which were launched upside down, and the pre-cast concrete dam in connection with the Chute-a-Caron development which was built on end and tipped into the river.

The Little Belt bridge is an important structure crossing a strait called the Little Belt which joins the Baltic and the North seas. It contains a number of spans of considerable length and the depth of water at the pier foundations ranges from about 80 ft. to 120 ft., the tallest pier having a total height of 223 ft. from its top to the bottom of the caisson. The caissons for the main piers were of the dredging type and of novel design. They were 142 ft. long by 74 ft. wide, rectangular with rounded ends. The sides were formed by a continuous ring of steel cylinders encased in concrete and connected together with a thick concrete slab forming the deck of a working chamber, thus providing for the use of compressed air if required. One of the novel features of this caisson was that the ring of cylinders which formed a sort of cutting edge was scribed to fit the contours of the rock, thus making launching in the usual way somewhat difficult. This whole structure was therefore built on launching ways upside down and was launched as one would launch a ship, and it was afterwards turned through 180 degs. while afloat through manipulation of ballast.

In connection with the Chute-a-Caron development it was necessary to close off a channel in which the current was so swift that conventional methods were deemed to be difficult and possibly impracticable. The dam, in the form of a large concrete block scribed to fit the bottom of the channel, was built on end on one bank and this pre-cast structure was then tipped into the river.* As built this was 92 ft. high, 45 ft. wide and 40 ft. in maximum depth, and weighed approximately 11,000 tons. This scheme proved to be a complete success.

In closing the author wishes to express his appreciation for valuable information regarding railroad practice furnished by C. P. Disney, bridge engineer of the Canadian National Railways, and P. B. Motley, M.E.I.C., engineer of bridges of the Canadian Pacific Railway, and to C. S. Bennett, A.M.E.I.C., acting chief engineer in Halifax for the National Harbours Board, for information relating to Halifax Harbour. He desires also to express his appreciation to L. H. Burpee, A.M.E.I.C., of his own staff for the research work he has done concerning this subject.

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*See The Engineering Journal, October 1930, p. 599; March 1931, p. 68.

# Freight Hauling in the Undeveloped Territories of Canada

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SUMMARY.—Gives brief notes on the cost of transport by canoe and dog-teams, and on road building in the bush, followed by a discussion of summer and winter freighting by water, horse-teams, motor trucks, and tractors with trains of sleighs.

Canada, comparatively speaking, is a young country, covering a large area, sparsely settled, having an unusually rigorous climate and endowed with great natural resources.

Our population of approximately eleven million, if spread over the entire land area of Canada's 3,466,556 square miles, would give a density of 3.17 persons per square mile, which is extremely low. Our population is approximately two and a half million less than that of the State of New York. Examination of a density population map of Canada, it is safe to say, would reveal that 95 per cent live within a belt formed by the International Border or the north shore of the Great Lakes and a parallel line 150 miles north, except in the prairie provinces of Saskatchewan and Alberta, where this belt should be increased to 300 miles.

In general, most of the territory north of this belt is undeveloped, and except for a few towns and camps, chiefly connected with mining and forestry, the country is inhabited by Indians, trappers, prospectors and hunters.

There is a great variation in temperature, being hot in summer and very cold in winter. Along the southern boundary of this undeveloped territory the summer temperature will occasionally reach 90 deg. or higher, but only for a few days. In winter, however, the temperature over much of it drops as low as 50 deg. below zero and will remain below zero for weeks at a time. Under average climatic conditions, the lakes and rivers begin to freeze over during the first two weeks of November, and the ice is generally thick enough to carry teams by the second week in December, and heavy loads about January 1st. The ice is usually good for freighting purposes up to April 1st. The snowfall varies considerably, being lighter in the prairie provinces than in Ontario and Quebec, where the total fall for the winter often amounts to between 8 and 10 ft.

Stretching across the continent are two railway systems. The Canadian Pacific is the southerly with a few branch lines extending into the north country. The Canadian National takes a more northerly route, and it is from this railway that most of the freighting into the undeveloped territories starts.

The country in which most of this freighting is being carried on is literally dotted with lakes and rivers, and in the low lying portions there is a great deal of muskeg. The land, except where fires have occurred, is well forested.

The foregoing is a brief description of the country in which freighting is being conducted for the development of our more remote natural resources of forestry, mining and water power.

Before proceeding to the more modern phases of transportation in such undeveloped territories, it might be interesting to look at the older methods of freighting, which are, to a limited extent, still in use to-day.

In summer canoes are used. These are usually 18 to 19 ft. in length with a beam of 46 in. and weigh about 160 lb. These will carry between 1,200 to 1,400 lb. of freight. Latterly, outboard motors are being employed, reducing the labour and increasing the speed.

The Hudson's Bay Company gives the following information regarding the freighting between Norway House and Island Lake, a distance by river of about 185 miles. Along the route there are ten portages, one of which is four miles long with the others varying from 100 yards to ¾ of a mile. The round trip usually takes ten to twelve days, depending upon conditions. Indians are employed and they supply their own food, canoes and motors. When the latter are used one motored canoe usually tows two or three others. For the transference of this freight the company pays 9c per lb. or at the rate of about $1.00 per ton mile. The rates for such work will vary, depending upon the difficulties of the route.

In winter toboggans or dog sleds are used. Five or six dogs make up a team when freighting by toboggan, while eight to ten are used on the Eskimo sled or kometik. The former is generally used over soft snow; on an unbroken trail it will make 15 to 25 miles per day, and on a broken one 25 to 40. On the other hand, the kometik is mostly used in the open on hard packed snow and will travel 25 to 40 miles per day.

Toboggans are loaded to about 70 lb. per dog, while the kometik may be loaded to 100 or 125 lb. per dog.

Kometiks are used between Moose Factory and Rupert's House, a distance of about 95 miles. It takes between eight to ten days to make the round trip, including a rest at Rupert's House and delays on account of weather. There are 8 to 10 dogs to a sleigh, on which is loaded from one thousand to twelve hundred pounds. The Indians supply their own food, sleighs and dogs, and are paid about $100 for the round trip, or $1.80 per ton mile.

### Freighting by Teams

Until comparatively recently, the horse drawn wagon or sleigh has been the universal means of freighting (the railways being excepted) and is still largely used. For short distances of two or three miles, the horse drawn sleigh on good iced roads still successfully competes with any mode of transportation.

Table I

Summer Team Freighting

Day's work 22 miles — Hauling outwards, return light.

| Miles hauled | 11 | 22 | 33 | 44 | 66 |
|---|---|---|---|---|---|
| Days absent from depot... | 1 | 2 | 3 | 4 | 6 |
| Pay load lb.*.............. | 1400 | 1267 | 1167 | 1067 | 867 |
| Cost per ton mile.......... | 80.2c | 89c | 96.5c | $1.05 | $1.26 |

Winter Team Freighting

Day's work 25 miles — Hauling outwards, return light.

| Miles hauled | 12½ | 25 | 37½ | 50 | 75 |
|---|---|---|---|---|---|
| Days absent from depot..... | 1 | 2 | 3 | 4 | 6 |
| Pay load lb.*.............. | 2400 | 2267 | 2167 | 2067 | 1867 |
| Cost per ton mile.......... | 41.2c | 49.5c | 51.9c | 54.3c | 58.6c |

*The reduction in pay load is due to the necessity of carrying food and supplies; the return journey is made without pay load.

An average 1,550-lb. horse will eat 26 lb. of hay and 24 lb. of oats per day, and in the summer on the ordinary portage trail a team will haul an average of 1,400 lb. about 22 miles per day. In winter on the same trail it will haul about 2,400 lb. and make about 25 miles.

It has been found that over a number of years the depreciation, maintenance, and miscellaneous costs pertaining to the upkeep of a horse and equipment amount to 45 cents per day over its working season, probably eight months of the year. Based on the above figures, and allowing $65.00 per month for teamster's wages, including board, and a 20 per cent allowance for time of barn boss and overhead, all of which amounts to $6.18 per working day per team, the rates shown in Table I have been worked out.

The distances have been taken to give full days travel from the main depot and return. The rates would, therefore, not be true for intermediate distances which would allow the teamster to return to the depot and have time to spare.

The Canadian International Paper Company has recently introduced a horse drawn wagon with pneumatic tires and ball bearing wheels, which under test has proved to be about twice as economical as the old iron-tired wagon and not nearly so hard on the horses.

The main features of the wagon are the 2¼ in. by 2¼ in. steel axles fitted with roller bearings and the 19 in. by 8 in. pneumatic tired wheels such as are ordinarily used on motor trucks. The rest of the wagon is constructed in the usual manner.

A comparative test gave the following result:—

| | 5 new type rubber tired wagons | 4 old type iron tired wagons |
|---|---|---|
| Total number of trips | 175 | 162 |
| Total distance loaded | 723.5 miles | 751 miles |
| Total cost | $665.00 | $810.00 |
| Total amount portaged | 305,000 lb. | 143,600 lb. |
| Average distance loaded per trip | 4.14 miles* | 4.61 miles |
| Range of loads | 1,100 to 3,000 lb. | 600 to 1,600 lb. |
| Average load | 1,775 lb. | 880 lb. |
| Average ton miles per trip | 3.67 | 2.03 |
| Cost per load | $3.80 | $4.97 |
| Cost per ton mile | $1.04 | $2.45 |

*For the first trip over a road cut by iron tires the loads were limited to between 800 and 1000 lb.

### Sleigh and Wagon Roads

In the past, winter portage roads have cost between $400 to $500 per mile, not including any bridges over 25 ft. span. Wagon roads usually cost between $750 and $800 for a 12 to 15 ft. right-of-way, roughly levelled off, including considerable corduroy, but no gravelling.

### Freighting Conditions

Freighting into undeveloped territories is carried on chiefly by companies engaged in forestry work, mining, and the construction of dams, hydro-electric power developments, transmission lines and pipe lines. Each enterprise presents its own problems and each has to be dealt with according to the conditions and requirements of the particular case.

The forestry industries have each year to freight in their camp supplies, which for a paper mill of any size amounts to a considerable tonnage. (It takes about 30 lb. of supplies of all kinds per cord of wood, and it requires approximately 1¼ cords of pulpwood to make a ton of newsprint.) For this purpose a good trucking road is usually built which is kept open for winter traffic. The motor truck has practically supplanted the horse drawn vehicle for freighting. Logs must be hauled from skidding yards to a drivable stream or a railway. If the operation from a skidding yard is to be only for one season, or of a temporary nature, then usually a winter road will suffice, but if it is to last for several seasons then a good truck road may be warranted. More than 98 per cent of the total hauling done by these companies is for the transportation of logs and less than 2 per cent for supplies.

In the case of the mines, the condition of the mine, whether a prospect or a producer, the type of ore produced and whether there is only one mine or several in the district, also its location in regard to a railway or a navigable route, are all factors in determining the method of freighting. If a mine is a producer it generally requires a year-round method of transportation, except possibly during the freeze up and break up seasons.

In regard to construction the conditions laid down in the specifications (usually the time of letting the contract, the ordering and delivering of material, and the length of time allowed to complete the work) govern the method of freighting. If year round freighting is too expensive, then winter or summer transportation must be adopted, in which case provision must be made for light freighting during the alternate season.

Confronted with a particular freighting problem, one should consider not only the requirements of the work in hand, but also the climatic and topographical conditions of the locality. The quickest and best way to become familiar with the topography is to fly over the proposed route with a map, noting thereon any special features. If a map is not available a photographic mosaic can be made which will be of great assistance in laying out the route.

### Water Freighting

Climatic and seasonable conditions have a big influence on waterborne transportation. The lakes and rivers are usually open for navigation from the 1st or 15th of May to the 15th or end of October depending upon the location and the season. High water generally occurs during June with the low stage in September, after which fall rains cause an increase in water levels.

Water transportation is the cheapest method of freighting for the longer distances when goods can be loaded direct on to boat or scow and conveyed to their destination over an unobstructed water course with only an unloading charge added. Unfortunately this condition is seldom obtainable, but due to cheapness of water freighting it is often possible to absorb some other charges and still handle freight at a cheaper rate than could otherwise be done.

Some of the methods employed to overcome obstructions to through navigation are:

(1) Marine railway. A railway is built across the portage with the track extending into the water at both ends. A carriage is run down the track into the water and the scow is floated on to it. The carriage with scow is then hauled over the railway and the scow is floated off at the far end. When these railways are used the scows are generally limited to about 15 tons capacity.

(2) Freight is unloaded from the scows on to a railway, car, truck or tractor, portaged across and loaded on to scows at the other end. A derrick is generally used to load and unload.

(3) An alligator tug or cable engine is often used to assist tugs and scows up rapids which are too swift for navigation under their own power.

(4) Locks and canals are seldom used except under ideal conditions, as they are usually too expensive.

The following are a few cases of water transportation into undeveloped territories.

Freight into the Pickle Crow district is transported by water between Hudson and Doghole Bay on Lake St. Joseph, a distance of 182 miles, divided into three stages. Hudson to Nattaway Falls, 97 miles; Nattaway Falls to and across Root Portage, 25 miles; Root Portage to Doghole Bay, 60 miles. In the second stage there are three marine railways and at Root Portage there is a four mile standard gauge railway. Here the cargo is unloaded, placed on flat cars, portaged across and again loaded onto scows. The charge for this entire operation is $23.00 per ton, or 12.8c per ton mile.

From Hudson to Red Lake, a distance of approximately 175 miles, in which there are five marine railways, the charge is $23.00 per ton, or 13c per ton mile. For the first stage of this route, a distance of approximately 110 miles, the charge is $10.00 or 9c per ton mile.

The Hudson's Bay Company—Mackenzie River Transport, quote rates for package freight on the Mackenzie River, which when converted to a ton mile basis give the results shown in Table II.

Table II

| | | | Per ton mile |
|---|---|---|---|
| Waterways, Alta., to Chipewyan | — 187 miles | — rate | 8.03c. |
| Waterways, Alta., to Goldfields | — 127 miles | — rate | 7.00c. |
| Waterways, Alta., to Ft. Fitzgerald | — 287 miles | — rate | 6.08c. |
| Waterways, Alta., to Ft. Smith Dock | — 303 miles | — rate | 13.2c. |
| Waterways, Alta., to Resolution | — 507 miles | — rate | 13.8c. |
| Waterways, Alta., to Hay River | — 582 miles | — rate | 13.75c |
| Waterways, Alta., to Simpson | — 816 miles | — rate | 13.5c. |
| Waterways, Alta., to Norman | —1,120 miles | — rate | 11.6c. |
| Waterways, Alta., to Aklavik | —1,661 miles | — rate | 7.23c. |

Between Fort Fitzgerald and Fort Smith there is a 16-mile portage. Large shippers can obtain a discount on the rates given.

On a short stretch of river and lake between Amos and Sullivan Mine, the rate is 25 cents per 100 lb. which over the distance of 45 miles is equivalent to 11 cents per ton mile.

A pulp and paper company which does some water transportation gives a cost of 3.8 cents per ton mile for transporting 794 tons of supplies a distance of 42 miles. This includes all operating and maintenance costs on boats, also their insurance and depreciation. It does not include any overhead expenses, or any shore costs such as maintenance of wharfs, warehouses, etc.

It should be mentioned that by far the largest water transportation business in our undeveloped areas is that of towing and driving logs for the forestry industries.

In a paper read before the Woodlands Section of the Canadian Pulp and Paper Association in 1930, entitled "Survey of Tow-Boats in Eastern Canada" by L. R. McCurdy, he states that "In eastern Canada the capital invested in pulp-towing boats is about $2,000,000." He also gives twenty-one examples of the cost of towing and from these has derived the following formula for the approximate cost of towing:

$$C = \frac{0.6}{M} + 0.5$$

Where $C$ = cost per cord-mile in cents

$M$ = number of millions of cord-miles towed.

This formula should only be applied where the quantity to be towed is over 500,000 cord-miles. For smaller quantities the cost per cord-mile rises too rapidly.

Three of the examples mentioned appear in Table III:

Table III

| | Example 1 | Example 2 | Example 3 |
|---|---|---|---|
| Total yearly operating cost, excluding depreciation, insurance, etc. . . | $27,170 | $6,283 | $3,595 |
| Average size of raft in cords. . . . . . . . | 6,000 | 3,000 | 1,400 |
| Distance towed in miles. . . . . . . . . . . . | 120 | 15½ | 19 |
| Cord-miles towed by boat. . . . . . . . . . . | 4,416,000 | 1,114,119 | 583,000 |
| Operating cost per cord-mile. . . . . . . . | 0.616c | 0.566c | 0.616c |
| Total yearly cost, including depreciation insurance, etc. . . . . . . | $30,920 | $11,863 | $10,095 |
| Total cost per cord-mile. . . . . . . . . . . . | 0.70c | 1.065c | 1.73c |
| Total cost per ton-mile. . . . . . . . . . . . . | 0.28c | 0.426c | 0.693c |

Summer Land Freighting

Summer transportation is chiefly a problem of roads and in this connection it must be borne in mind that the country is rather broken, and, generally speaking, has a large number of lakes and rivers, also that the low lying lands are usually swampy and consequently the roads must keep to the higher levels or else corduroy has to be liberally used. In the more developed mining areas the provincial governments are now building roads which formerly were undertaken privately.

Motor trucks, trucks and semi trailers, tractors and horse drawn wagons are the means used to convey the freight, and the choice of equipment will depend largely upon the type of road.

The pulp and paper companies have in the past few years amply demonstrated that, provided there is sufficient tonnage to warrant the expenditure, it pays to build good truck roads. These are not built to any particular standard, but are the cheapest roads that will serve their best

**Fig. 1—Caterpillar tractor equipped with Trail-Builder building a Logging Truck Road.**

interests, which is to attain the lowest total for all items entering into transportation costs. Actually, the main roads throughout their limits, while narrow, usually ten to twelve feet wide, are good.

With the advent of fast moving motor trucks for portaging supplies, better roads have come into being. They are more carefully located and an endeavour is made to keep the grades within reasonable limits. There is better alignment and, most important of all, the surface is receiving greater attention. For high speeds a smooth surface is essential. The result is that heavier loads are being carried at considerably higher rate of speed with consequent reduction in freighting costs. Speeds of twenty miles per hour can readily be maintained.

The United States Department of Agriculture, Forestry Service, has issued a "Forest Truck Trails Handbook 1935," which prescribes standards for the various classes of minor forestry highway projects and serves as a reference manual for their location, construction, and maintenance. This book is well worth reading by those interested in the subject.

In the last few years the method of road building has greatly improved and costs considerably decreased by the use of modern equipment, such as the high powered tractor with road builder or bulldozer attachment, heavy road grader, trucks, light crawler shovels, and portable gasoline compressors.

The cost of roads will vary considerably, depending upon the character of the country through which they are built. A few examples of the cost of truck roads are given:

*Case 1.*—In 1929-1930 a large lumbering concern in Ontario built an 8-mile extension of first class truck roads for $4,250 per mile which included the construction of a fairly large bridge. The right of way was cut 50 ft. wide through heavy pine timber. The roadway was stumped and graded for a width of 24 ft. and was heavily gravelled for 12 ft. Considerable rock work was involved. Side ditches provided the drainage with log culverts where necessary. The equipment used was:

A ten-ton caterpillar tractor for stumping right-of-way.
A super-mogul grader, drawn by the above mentioned tractor.
A portable gas driven air compressor.
A gas driven shovel, and motor trucks.

*Case 2.*—A woods manager of one of the pulp and paper companies, who has a particularly difficult Laurentian territory in which to build roads, states that since using modern equipment his road costs have dropped 20 to 25 per cent, and that his present costs are between $2,200 and $2,500 per mile. That he gets a much better road foundation and in so doing has considerably reduced his maintenance costs.

*Case 3.*—Fifty-three miles of road built four years ago, located 150 miles north-east of Montreal, and in a comparatively easy country for road construction, cost $1,563 per mile. Labour rates were $40 to $45 per month and board. The main features of the road were:

Right-of-way cleared for width of 32 ft., stumped for 28 ft., 22 ft. between ditches, and with a 10-ft. width of gravelled surface. There were 4 bridges of approximately 150 ft. each and 10 of between 75 to 80 ft. in length. These bridges consisted of crib piers supporting log spans 15 to 20 ft. long. The stringers were covered with cross logs and these in turn had two 30-in. planked running strips.

Maximum grade against the load, 11½ per cent.
Maximum grade with the load, 16 per cent.
Equipment used—Two No. 30 caterpillar tractors.
One No. 88 road grader.
One portable air compressor.
Two jackhammers.

*Case 4.*—A road being built by the same company through difficult country and to approximately the same standards, involving considerable rock work, but with the use of modern equipment of the medium powered type, is averaging $2,100 per mile.

In a recent paper on "Logging Roads"* by J. D. Gilmour, consulting logging engineer, he states that with powerful modern road making machinery, good truck trail roads can be built through the Laurentian Mountains at an average cost of $1,200 per mile ready for gravelling, also that the cost of gravelling will vary considerably, but can be averaged at $500 per mile. On jack pine sand plains there are stretches where good truck trails can be built for as low as $400 per mile.

These roads are used all the year round and require less preparation and maintenance and give better service than the snow and ice road built for winter traffic only.

Maintenance work should be continuous, and an endeavour made to anticipate trouble rather than have to repair heavy damage after it has occurred. The annual cost for maintenance on these roads varies between $50 to $100 per mile.

The Ontario company referred to in Case 1. portages its camp supplies a distance of 90 miles. In 1927 to 1929 the charge was 15c per ton mile, but as the roads were improved and hired trucks became cheaper the rate dropped to 9c.

The cost of operating four 2-ton Ford trucks carrying supplies and doing general trucking work etc., over a year's run of 55,500 miles was 11.85c per ton mile, or 14.8c per mile.

The details of these costs are:

| | |
|---|---|
| Wages | $0.0429 per ton mile |
| Gasoline | .0312 per ton mile |
| Oil | .0052 per ton mile |
| Tires | .0080 per ton mile |
| Repairs | .0312 per ton mile |
| Total | $ .1185 per ton mile |

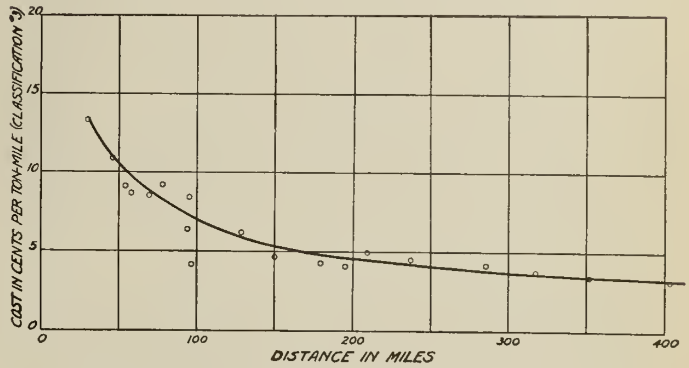


**Fig. 2—Cost of Inter-City Truck Freighting out of Montreal.**

Another logging company figures the cost of hauling supplies at 13.3c per ton mile.

Summer truck freighting in the Northern Quebec mining country runs about 30c per 100 lb. for 45 miles, or 13⅓c per ton mile over country roads.

Figure 2 gives a graph showing the charges per ton mile for inter-city truck freighting out of Montreal for goods under railway classification No. 3. The rates are for less than truck load lots.

In comparing these rates with those into undeveloped territories it must be remembered that in inter-city trucking freight is transported in both directions, that the roads are paved or well maintained, and that there are no road building charges to be written off in a few years, or, as in the case of winter transportation, in three months operations.

Tractors are seldom used for summer freighting, and when they are, it is generally under very adverse conditions. The nearest example of a summer tractor haul is one covering a period of twenty months and occurred several years ago. At that time the tractor was more in the development stage and is not to be compared with that of to-day. The haulage was over a dirt road with no attempt at surfacing, except to build up the soft spots with corduroy, bush and gravel. It was dusty in dry weather, and muddy in wet, and had an adverse maximum grade of 15 per cent.

The cost, covering 1,280,000 ton miles, exclusive of construction and maintenance of roads, but including all operating expenses, loading, maintenance of equipment, insurance, overhead and depreciation to extent of 50 per cent of the value of equipment, was 31½ cents per ton mile. In winter the average load per trip was 20 tons, 11 of which was on the tractor and the balance on a sleigh. In summer, the average load was 11 tons carried on the tractor.

### Winter Freighting

By far the greater amount of freighting in our undeveloped territories is carried on during the winter, primarily due to climatic conditions and also to the relative ease with which loaded sleighs may be hauled over ice and snow roads.

Advantage is taken of the frozen condition of the lakes, rivers and muskegs to transport goods to places which are practically inaccessible at other seasons except by aeroplane.

*Canadian Pulp & Paper Assoc., Woodlands Section, 1937.

Roads are the main feature governing the efficiency of winter transportation. Poor roads mean slow speeds, light loads, and heavy costs in maintaining equipment.

Winter roads may be divided into two classes, depending upon whether they are on land or over frozen bodies of water.

### Winter Roads on Land

In regard to the building of land roads, one should consider whether the road is to be used for one or more seasons, and the tonnage to be freighted should be known, since the type of road bed should depend upon the density of traffic.

Winter land roads will conform in general to most of the requirements for good truck trail roads. There are, however, a few other conditions relevant to such roads which should be borne in mind;

(1) To minimize trouble from drifting snow, it is advisable to locate the road through the more densely wooded areas and to keep on the windward side of lakes, rivers and open spaces.

(2) Where possible, avoid crossing swamps and muskegs. Often these surfaces do not freeze to any depth, especially if there has been an early fall of snow, and consequently give considerable trouble unless they are corduroyed. As muskegs generally are treeless they start to thaw early in the spring and often cut short the haulage season.

(3) If the road is to be used by sleigh trains, the radius of curves should be kept as long as possible. A minimum of 60 ft. radius on the level and 100 ft. on a grade is suggested. It is recommended that where curves occur on a grade, the grade should be reduced. This is specially noticeable when it exceeds 4 per cent. Iced ruts on a curve are a great assistance as the friction is reduced to a minimum and the sleighs are held in position on the road.

### General Requirements of Land Roads

If much hauling is to be done the right-of-way should be cleared for a width of from 20 to 30 ft. Twenty-five feet is a good width, unless extra wide sleighs are to be used. The right-of-way should be cleared of all stumps and

Fig. 3—Tractor-Train consisting of Caterpillar Tractor, Water Tank and 17 Sleighs (only part shown in photograph) of Logs containing 125,000 f.b.m.

projecting stones down to ground level. The brush and branches should be burned and any logs not used piled at the edge of the clearing. Humps should be levelled off and hollows filled in with earth or logs so as to give a generally uniform surface. On side hills, the road is usually made half cut and half fill, with logs being used to hold the fill. In such cases the road should not be less than 14 ft. wide. Rock work and heavy cuts and fills should be avoided as much as possible. All creeks and fast flowing rivers should be bridged. These bridges usually consist of log stringers spanning between crib piers. The stringers are covered with cross logs with running strips spiked down to them.

Under exceptional circumstances floating bridges are sometimes used. Hennessy and Hennessy Limited built two such bridges, located several miles north of the C.N.R. Transcontinental Railway. The design and construction display considerable ingenuity and resourcefulness, making the most use of materials readily available.

The bridges consist of nine main stringers of three logs each. These logs are the longest and largest that could be found in the vicinity, being about 60 ft. long and 2 ft. 6 in. to 3 ft. diameter at the butt and about 8 in. at the top. The three logs are staggered so that there are two logs past any joint. These logs are spiked to each other and securely bound together by ⅞ in. cables placed approximately at 4 ft. centres and made tight by wooden wedges. The nine main sets of stringers are anchored to shore and held together by cross logs averaging 8 in. to 9 in. in diameter and 27 ft. long, spiked to the stringers. On top of these cross logs are two running strips, each three feet wide and set to the gauge of the tractors. The logs forming the running strips are roughly adzed flat on two sides and are about 4 in. thick. These are spiked down to the cross logs. In between each of the three outer sets of stringers is placed a ¾ in. cable and these four cables are run from shore to shore and anchored. At the quarter points of the span, guys are taken upstream and anchored to shore, thus keeping the bridge in line. The road surface is iced over.

One of these bridges is floating in a rapid, and spans 350 ft. It supports a live load of 25 tons consisting of an 11-ton

Fig. 4—Tractor-Train plowing out the Road and Transporting a Transformer.

tractor and two loaded sleighs of 7 tons each. When crossing the bridge the tractor and sleighs travel in about a foot of water.

At the end of the season the bridge is cut loose from one of its shore anchorages and allowed to swing downstream, giving a free passage for the spring floods. In the fall the bridge is hauled back into position.

### Winter Road Surface

With certain minor variations, the type of winter roads most commonly in use are:

(1) Snow surface, snow base.
(2) Ice surface, snow base.
(3) Ice surface, ice base.

### Snow Roads

Preparation of the road is commenced when between six to twelve inches of snow has accumulated. The snow is broken down and compacted for the width of the roadway (usually about 10 ft.) by tractor, roller, or a long wooden V shaped plow. The road bed is given a final levelling off by hand, or by hauling over it a long drag with square cutting face which cuts off the remaining humps and deposits the snow in the hollows. By passing a tractor or lightly loaded sleighs over the road a few times a good compacted snow base will be established, and incidentally the plows or drags should be made to operate in either direction to save turning.

A first class snow road should be kept plowed out to keep the surface close to the ground. If desired, a rutting plow can be used, but usually the sleighs will soon cut their own ruts.

Snow roads of a poorer class, used only for light density traffic, have little done to them after the original breaking out and levelling up.

On these roads the tractors and sleighs follow the same path each time they pass over the road and compact whatever snow may have accumulated in the ruts. This results in the formation of two ridges, each about 20 in. wide, on which the sleighs and tractors must travel.

These ridges are not compacted tightly, are quickly affected by mild weather, and readily develop pitch holes.

The crawler type of tractor is the only one that can operate on this type of road. If the tractor gets off the path it usually has to cut loose from its train, turn off the road into the snow, then back up on to the road, turn, and connect up to the train again. Another type of snow road is where the tractor plows out the road each time it passes.

Roads with snow base and iced surface are made by watering the compacted snow. The entire width of road can be iced, but generally only the sleigh tracks are so treated. This type of road is usually rutted to the gauge of the sleighs, especially if the sleighs are of wider gauge than the tractor or trucks, which is a desirable feature. It is also advisable to build up solid ice shoulders to prevent the sleighs from slewing.

For icing the roads, water in sufficient quantities should be available at frequent intervals. The watering device consists of a wooden box water tank (capacity from 200 to 500 cu. ft.) mounted on sleighs, and equipped with a filling arrangement consisting of a water barrel sliding up and down an inclined skidway, the power being furnished by horse, truck, or tractor. It takes about thirty minutes to fill a 300 cu. ft. tank if a horse is used. Gasoline driven self priming pumps are also used for this purpose, and they should be housed and heated. It takes approximately 3,800 cu. ft. of water to cover one mile of roadway 8 ft. wide to a thickness of one inch.

Ruts are desirable when sleigh trains are used. These are made by pulling over the road a rutter which cuts two grooves to the gauge of the sleighs.

### Maintenance of Roads

Winter roads require continual care and attention if the surface is to be kept smooth, iced, and free from snow.

Snow should not be allowed to accumulate on either the iced or first class snow road. After every storm the road should be plowed and ruts cleaned and watered. In good weather the ruts should be cleaned, regrooved, and watered at least twice a week.

To keep the roads clear of snow, plows are either attached to the haulage units and operated when necessary, or regular plow units are sent over the road when required. Where traffic is heavy and continuous the former method is generally all that is necessary.

On the poorer snow roads usually little can be spent on maintenance, yet if pitch holes are allowed to develop the speed of the tractor trains is greatly reduced, and heavy maintenance equipment costs are incurred. In this case, about the only thing that can be done, is to haul a drag with an adjustable cutting edge behind each train to cut off the humps and fill in the hollows. These drags should be not less than 20 ft. long, and are used mainly when returning light. The drag should be built so that cross pieces between the skids have sleigh clearance.

Where sleigh trains are used on iced rutted roads the effectiveness of the icing is often greatly reduced by using sleighs of the same gauge as that of the haulage unit. The tractor treads or chained truck wheels are continually filling the ruts with chipped ice or snow, thereby increasing the frictional resistance. In the Lake States wider gauges are used to overcome this condition.

Maintaining and icing of winter roads is expensive, running as high as $350 per mile per season. Seventy miles of road, of which approximately 70 per cent was over lakes, averaged $310 per mile per season. The cost of icing and rutting will vary and may amount to half of that figure depending upon how much work is done. To counterbalance this latter charge it should be remembered that twice as much can be hauled over iced as over snow roads.

### Roads on Lakes and Rivers

While the freezing of the lakes, rivers and muskegs is a very real advantage to winter freighting yet it is accompanied by hazards and difficulties which must be guarded against and overcome.

As a general rule, heavy freighting on lakes and rivers should only be resorted to north of the Canadian National Transcontinental Railway, or where the temperature will stay at zero or below for a considerable portion of the winter.

(1) Some of the hazards of freighting on lakes and rivers are: Use of ice before it is sufficiently thick. It may be considered safe to put lightly loaded teams on ice when it has attained a thickness of 6 inches. It requires 18 in. to support a medium weight tractor and train and 24 in. for heavily loaded ones. To hasten the formation of ice on the roadbed the snow should be plowed off as soon as the ice is sufficiently strong to sustain a team of horses. The surface should be kept clear of snow for at least two and a half times the width of the roadway. Corduroy, twelve to sixteen feet long, frozen into the ice will help to distribute the load and is often used for short distances, such as across rivers or small lakes that are slow to freeze.

Fig. 5—A Tractor in difficulties having broken through the ice.

(2) Warm springs entering a lake or river from shore or underground. To avoid the former the road should be located sufficiently far from shore so as not to be affected by them. Underwater springs seldom occur,

but are a real danger unless known about from previous experience.

(3) Good thick ice is seldom found on shallow or muddy lakes. For this reason they should be avoided if possible.

(4) Expansion ridges. These are formed in milder weather when expansion is taking place, and cause the ice to be pushed up, forming a ridge which sometimes is several feet high. These can be cut down to permit the road to pass.

(5) Slush conditions. Slush is formed by the weight of snow causing the ice to sink so that water floods the surface and saturates the snow. This constitutes one of the greatest dangers, as a driver cannot see the actual surface he is driving over; also, the ice, while it does not melt under the water, deteriorates to a certain extent. Slush will not freeze if there is any snow on top of the water. If one must traverse such lakes and rivers, there are three methods of dealing with this difficult condition.

The first method is to plow a road through the slush with a tractor. This removes the snow and will permit the water to freeze. In this case the road should be plowed out to a width of at least 25 ft.

The second method is to keep compacting the snow from the beginning of the season by means of a roller or drag, so that a road is built up which will not be affected by the slush when it occurs.

The third method is to wade through it with light or medium weight tractors hauling a train of lightly loaded sleighs (not more than 6 to 7 tons for tractor or sleigh). When this method is adopted the trains usually operate in pairs, or several together, and are preceded by a plow. Generally, no cabs are placed on the tractors, so the driver has a clear opportunity to jump at the first sign of danger.

One of the difficulties of freighting on a wide expanse of open surface is to keep the road free from drifting snow. This may be minimized by locating the road near the shore from which the prevailing winds blow, and by plowing several deep and wide furrows to windward of the road. Plows, either as individual units, or attached to the haulage units, are a necessity, and are the chief means of keeping the road open.

Where the road enters and leaves the ice the approach should be bridged by stringers, one end resting well up on shore and the other extending out onto the ice. These stringers should be corduroyed and the whole frozen together.

At the beginning of the season it is advisable to load the trains lightly. They should not follow one another too closely, but rather a time interval should be allowed, so that any cracks formed by the passing of the first train may have an opportunity to freeze together.

Later in the season, when good thick ice exists (about 3 ft.) the sleighs may readily be loaded up to 20 tons each.

### Equipment

The character and amount of equipment required for any particular freighting job depends upon the following:

(1) The amount of freight.
(2) Length of time in which to handle it.
(3) Distance to be hauled.
(4) Characteristics of the road, that is, the grades, curves and road surface. Whether the road is over land, or lakes and rivers, or both.
(5) Whether the freight will be delivered at a uniform rate to the loading yard throughout the haulage period. If this cannot be done, then the maximum rate of delivery for a given time should be known.

The following is a list of equipment and buildings used on a large winter freighting job for the transportation of construction materials and supplies.

*Buildings and Equipment at rail head and loading yard.*

1 Bunkhouse fully equipped.
1 Cookery fully equipped.
1 Blacksmith shop fully equipped.
1 Repair shop, containing a small lathe, drill press, small shaper.
1 Garage.
1 Warehouse and platform.
1 Office and staff house.
1 Barn.
1 Power house containing:
  1-45 kw. electric generator direct connected to a gasoline engine.
1 Oil house with a 1,000 gallon gasoline tank outside.

**Fig. 6—Tractor Trains passing. The two Tractors breaking out a Siding. Note Caboose on Train.**

*Equipment for Transportation.*

12 100 hp. Linn tractors with snow plow attached.
2 30 hp. tractors for yarding purposes at the terminals.
1 60 hp. tractor for making up the loaded trains.
150 Heavy duty sleighs, 60 in. gauge with tractor hitch, 3½ in. by 9 in. by 9 in. double end runners. ⅝ in. cross chains. 2 poles. ½ in. by 3½ in. concave steel shoes. 8 ft. bolsters.
150 Racks for above sleighs.
4 10 ft. by 20 ft. cabooses.
10 8 ft. by 12 ft. cabooses.
7 Water tanks.
4 Horse drawn snow plows.
7 Tank sleighs. Same as above but without bolster.
2 ½ ton service trucks.
1 Snowmobile (runners in front—track on 4 rear wheels).
1 Automobile.
1 Gas-electric shovel fitted up as a crane.
15 Teams.

Camps, consisting of a small bunk-house, cookery and stable, were built at the longer portages, or where necessary for the men attending to the icing operations.

At the distant terminus there was a bunk-house, cookery, and garage, to provide for the switching and unloading crew.

During a season this equipment handled 22,500 tons of freight a distance of 68½ miles over iced roads, 20,000 tons of which were freighted in sixty days.

Sleigh maintenance is a heavy item of expense and the strongest and stoutest sleighs made are none too strong for use in mechanical haulage. During the past year an all steel sleigh has been placed on the market. As far as known, however, it has not been tested under the severe conditions of tractor train usage.

### Operation

Careful planning and scheduling, with competent supervision and a reliable organization, while essential to the success of any job, is particularly so in the case of freighting in undeveloped territories, owing to the shortness of the season and the many difficulties to be overcome.

Tractors are expensive and should, therefore, be kept working to near capacity as much of the time as possible. To accomplish this the following points should be closely watched:

(1) No time should be lost by the hauling unit having to wait for loading or unloading.
(2) The hauling unit should be kept in good running order. It should be greased and oil changed at regular intervals. Once a week it should be thawed out and thoroughly serviced in a warm garage.
(3) A reasonable stock of the more commonly required spare parts should be kept on hand.
(4) The roads should be maintained in as good condition as possible.
(5) A sufficient number of spare drivers should be employed to ensure continuity of service.
(6) To properly supervise the operation, and for emergency calls, snowmobiles should be provided.
(7) Means of communication from frequent points along the route should be provided, either by telephone, wireless, or aeroplane patrol.

### Loading and Unloading

The work of loading and unloading should go on continuously, or at least to the extent of always having a full load ready to be moved out. There should be a sufficient number of sleighs so that the haulage unit will not have to wait for them to be loaded, unloaded, or repaired. The sleighs are loaded by hand except for the heavier pieces which require the use of jacks or derricks. Where trucks are used, a method of loading should be devised which will cut the loading and unloading time to a minimum.

Upon arrival of a train at its destination, the tractor will either distribute the sleighs to their unloading point, or cut off from its train and leave the distributing to be done by a small unit. On return to headquarters the same procedure is carried out except that the tractor is thoroughly serviced and overhauled. On large jobs, small tractors usually distribute the sleighs and make up the trains ready for the big tractor to hook on.

A train is made up of a caboose and as many sleighs as the tractor can readily haul. The crew consists of two drivers and two helpers operating in pairs on either six or eight hour shifts. While en route the train is kept continuously on the move except for stops due to mishaps, oil changes, greasings, and meals if the road is rough. The men sleep and eat in the caboose, which is about eighteen feet long, eight feet wide, and eight feet high, contains two sets of double deck beds, a small cook stove, water barrel, wash basin, table, cupboard, and shelves to hold provisions, etc., and at the rear of the caboose is a meat box. The meals are cooked while the tractor is in motion, a railing is placed around the top of the stove to prevent the pots from sliding off. The routine inspection, greasing and oiling, are usually done at the morning and evening meal hours. Life on these tractor trains is not all that could be desired, and few men endure it for very long. For this reason, and on account of sickness, spare drivers should be always available.

The average speed of a heavily loaded tractor train on a good iced road may be between two to three miles per hour depending upon the load and the make and type of tractor. The return speed will be between 4 and 7 miles per hour. As for example, it took an average time of twenty-three hours hauling 75 tons per trip to make $68\frac{1}{2}$ miles. The return took fourteen and a quarter hours. Time at main depot reconditioning, etc. six hours. Time at distant terminus two and a quarter hours. A train consisted of between 4 and 6 sleighs, one of which was a caboose. The average load per sleigh was 15 tons with maximum of 38. The maximum load hauled on one train was 112 tons.

On good snow roads, about the same speed can be made, but the load will be reduced about 50 per cent.

On a poor snow road of the raised compacted path type, a speed of $1\frac{1}{2}$ to $1\frac{3}{4}$ miles per hour is considered good.

Where there is a heavy density of traffic, there is a distinct trend toward the use of trucks, either operating as an ordinary truck or used as a tractor to haul a train of sleighs, the body being loaded to give traction. This is especially so in the forestry industries, where they are being used extensively, and have in many cases displaced the horse and the tractor for the haulage of logs and pulpwood.

The motor truck was not originally intended to serve as a haulage unit for sleighs, and under the very severe conditions some weaknesses developed, chiefly in the rear end. These troubles are being overcome by increasing the gear ratios between engine and axle, and by the use of dual driven rear axles.

For trucks to operate effectively the roads must have a solid base, and be kept free from loose snow. If they are to haul sleighs the road should be iced, rutted, and have solid shoulders. Under such conditions trucks can operate at a much higher speed than tractors, and haul considerably more per dollar of purchase price. Their operating and maintenance costs are less and capital investment smaller. Besides, there is more ready employment for them during the rest of the year.

As an illustration of the above, take examples Nos. 14, 15 and 16 on the cost sheet (Table IV) which covers the hauling of logs by the same company. In example 14 the hauling was done by two 100 hp. gasoline Linn tractors, while in examples 15 and 16 the haulage was done by two Diesel Badger Leyland trucks. The daily hauling capacity of the trucks and tractors is almost exactly the same, the trucks being able to make twice as many trips as the tractors, but haul only one half the load per trip. The relative costs covering the haulage and maintenance of equipment are as 2.961 cents per ton mile for the tractor is to 1.835 cents for the first year truck operation and 1.522 cents for the second year's operation. If depreciation is taken into consideration there will be a greater difference in favour of the trucks, especially as they are used in summer.

**Fig. 7—Tractor Train transporting Generator Spider and other Equipment.**

An interesting comparison is given by the same company of the costs of hauling operations covering loading, hauling, tanking, road upkeep and rolling, over the same road by team, tractor and Diesel trucks.

| | |
|---|---|
| Horse teams | 9.07c per ton mile |
| Gasoline tractor | 7.3c per ton mile |
| Diesel trucks | 6.2c per ton mile |

Table IV

Freighting Costs in Undeveloped Territories

HAULAGE BY TRACTOR

| Examples / Items | Units | No. 1 1928–29 | No. 2 1929–30 | No. 3 | No. 4 1935–36 | No. 5 | No. 6 1934–35 | No. 7 1935–36 | No. 8 | No. 9 1936–37 | No. 10 1935–36 | No. 11 | No. 12 | No. 13 1936 | No. 14 1933–34 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tonnage hauled.. | Tons | 22,556 | 12,648 | 809 | 3469 | 7000 | 3813 | 2513 | 608 | 545.1 | 880 | 4808 | 17,515 | 8132 | 36,082 |
| Distance hauled.. | Miles | 68.86 | 68.5 | 70 | 56.3 | 32 | 142.6 | 130 | 133.6 | 44½ Max. 52 | 34 | 29.68 | 29.68 | 20 | 4.65 |
| Ton miles........ | T.M. | 1,550,274 | 847,136 | 56,630 | 194,893 | 224,000 | 453,734 | 326,773 | 81,239 | 24,209 | 29,920 | 42,701 | 520,000 | 162,640 | 167,784 |
| Haulage season... | | Winter | Winter | Winter | Winter | Winter | Winter | Winter | Winter | Winter | Winter | Mostly Winter | Mostly Winter | Winter | Winter |
| Cost of loading... | $/ton | 0.981 | 1.22 | 0.49 | 1.31 | ... | 1.25 | 1.216 | | | {1.14} | | | | 0.122 |
| Cost of unloading. | $/ton | 0.478 | 0.778 | 1.26 | 1.28 | | 0.952 | 01.278 | | | | | | | |
| Roads | | | | | | | | | | | | | | | |
| Building....... | $/Mile | {702} | | | 212 | | | | | | | | | | |
| Preparing...... | $/Mile | | 147 | | | | | | | | | | | | 76 |
| Maintenance... | $/Mile | 315 | 305 | 57 | 93.5 | | 50.50 | 46.40 | | 6.25 | {74.00 | | | 18.5 | 428 |
| | $/T.M. | 0.014 | 0.0246 | 0.0073 | 0.0273 | 0.0212 | 0.0149 | 0.0132 | | 0.01194 | 0.0626} | | | 0.0023 | 0.0118 |
| Hauling operation | | | | | | | | | | | | | | | |
| Labour.. ..... | $/T.M. | 0.0116 | 0.0347 | | 0.0327 | 0.083 | 0.0329 | 0.0375 | | 0.03739 | 0.0563 | 0.021 | | 0.0076 | 0.00642 |
| Fuel........ | $/T.M. | 0.0210 | 0.01995 | {0.129} | 0.0313 | 0.032 | {0.0654} | {0.0591} | {0.0183 Av. over 2 yrs.} | 0.01477 | {0.0424} | {0.026} | {Hauling operation and maintenance of equipment 14.2 c. per ton mile for 6 Linn gas tractors} | 0.014 | 0.01142 |
| Lubricants..... | $/T.M. | 0.0048 | 0.00467 | | 0.0061 | 0.0085 | | | | 0.00712 | | | | 0.001 | 0.00083 |
| Miscellaneous.. | $/T.M. | 0.00422 | 0.00236 | | 0.0236 | | 0.00203 | 0.00237 | | | 0.0034 | | | | 0.00104 |
| Total of hauling operation...... | $/T.M. | 0.04162 | 0.06168 | 0.129 | 0.0937 | 0.1235 | 0.10033 | 0.09897 | | 0.05928 | 0.1021 | | | 0.0226 | 0.01971 |
| Maintenance of | | | | | | | | | | | | | | | |
| Haulage units.. | $/T.M. | {0.0336} | {0.0355} | {0.05} | 0.0467 | {0.0416} | 0.0406 | 0.0628 | | {0.00473} | 0.0428 | 0.046 | | {0.0075} | 0.0099 |
| Sleighs......... | $/T.M. | | | | 0.0360 | | 0.009 | 0.0119 | | | 0.01 | | | | 0.0018 |
| Overhead | | | | | | | | | | | | | | | |
| Supervision.... | $/T.M. | 0.0057 | 0.01 | | | {0.0322} | 0.00662 | 0.01015 | | | 0.0523 | {Above costs best of 6 tractors in example No. 12} | | {.0016} | 0.00196 |
| Head-quarters expenses..... | $/T.M. | 0.00104 | 0.00114 | | | | 0.0235 | 0.0075 | | | 0.02 | | | | |
| Insurance...... | $/T.M. | 0.00065 | 0.00275 | | | 0.0088 | 0.00487 | 0.00621 | | | 0.00946 | | | | |
| Camps........ | $/T.M. | 0.00805 | 0.0124 | | 0.01532 | | | | | | | | | | |
| Depreciation of equipment... | | No amoun | ts given. | | | | | | | | | | | | |
| Interest on capital invested | | No amoun | ts given. | | | | | | | | | | | | |
| General Information | | | | | | | | | | | | | | | |
| Cost of equipment (new) | $ | 201,920 | 201,920 | | | 167,677 | | | | 12,000 | | | | | |
| Haulage units.. | | 12-G-Linn | 12-G-Linn | | G-Linn | 10-G-Linns | G & D Linns | G & D Linns | D-Linn | 2-D-Caterpillars R-D 6 & 35 | 1-D-Linn 1-D-Cater 4-G-Cater | 1-G-Linn | 6-G-Linn | G. Lombard | 2-100 hp. gas Linns |
| Product hauled... | | Const. Mat. | Const. Mat. | Gen'l Frt. | Const Mat. | Const. Mat. | Const. Mat. | Const. Mat. | Const. Mat. | Gen. Supp | Const. Mat. | Const. Mat. | Const. Mat. | Hard Wood | 16 ft. Logs |
| Average number sleighs per train........ | | 4 to 6 | 4 to 6 | | | 1 | 4 to 5 | 4 to 5 | | 3 | 2 | | | | 5.94 |
| Average load per sleigh.... | tons | 15 | 15 | | | 11 | 10 | 10 | | 4¼ | | | | | 11.5 |
| Average load on haulage unit.. | tons | 6 to 10 | 6 to 10 | | | 11 | | | | 0 | | Load on body | Load on body | | |
| Average pay load per train | tons | 75 | 75 | | | 22 | 40 | 40 | | {R.D 6-14.2 35 12.15} | | | | | 66.58 |
| Average speed loaded....... | m.p.h. | 3 | 3 | | | | | | | | | | | | |
| Average speed light........ | m.p.h. | 4.9 | 4.9 | | | | | | | | | | | | |
| Duration of operation.... | | 3 mos. | 3 mos. | | | | | | | | | | | | 46 days |
| Road surface... | | Iced | Iced | Snow | Snow | Snow | Snow | Snow | Snow | Snow | Snow | Snow | Snow | | Iced |
| Fuel costs...... | c. per gal. | 22½c. | 22½c. | | 33.1c. | | | | | 15 | | | | 21.7 | 30.16 |

Note—Haulage units—If driven by gasoline engine denoted by "G"; if driven by Diesel engine denoted by "D".

Table IV—Continued

HAULAGE BY TRUCKS

| Examples / Items | Units | No. 15 1934–35 | No. 16 1935–36 | No. 17 1935–36 | No. 18 1935–36 | No. 19 1935–36 | No. 20 1936–37 | No. 21 1936–37 | No. 22 | No. 23 1935 | No. 24 1936 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tonnage hauled | tons | 33,178 | 29,159 | 10,951 | 58,000 | 20,489 | 25,250 | 23,300 | 100,000 | 2.5 av. ld. | 3.52 |
| Distance hauled | miles | 7.05 | 7.84 | 7.1 | 11.8 | 3.9 | 5.5 | 2.9 | 10 | 27,720 | 9130 |
| Ton miles | T.M | 233,805 | 228,606 | 77,752 | 684,555 | 79,909 | 138,875 | 67,500 | 1,000,000 | 69,300 | 32,117 |
| Haulage season | | Winter | Winter | Winter | Winter | Winter | Winter | Winter | Summer | All year | |
| Cost of loading | $/ton | | | | | 0.068 | 0.101 | 0.098 | | | |
| Cost of unloading | $/ton | | | | | 0.0852 | 0.047 | 0.047 | 0.62 (excl sand) | | |
| Roads | | | | | | | | | | | |
| Building | $/mile | | | 371.30 | 754 | | | | | | |
| Preparing | $/mile | 54.5 | 171 | 93.15 | | | | | | | |
| Maintenance | $/mile | 330 | 217 | 41.5 | 395 | 445 | 113 | 340 | | | |
| | $/T.M. | 0.0114 | 0.00975 | 0.0183 | 0.00682 | 0.0233 | 0.0063 | 0.0189 | | | |
| Hauling operation | | | | | | | | | | | |
| Labour | $/T.M. | 0.00455 | 0.00420 | 0.0114 | 0.00375 | 0.00431 | 0.0021 | 0.0042 | 0.013 | 0.0427 | 0.0226 |
| Fuel | $/T.M. | 0.00175 | 0.00274 | 0.0122 | 0.00485 | 0.00644 | 0.0061 | 0.0072 | 0.009 | 0.0312 | 0.0188 |
| Lubricants | $/T.M. | 0.00047 | 0.00076 | 0.0005 | 0.00025 | 0.00060 | 0.0007 | 0.0005 | 0.001 | 0.0052 | 0.0020 |
| Miscellaneous | $/T.M. | 0.00086 | 0.00044 | | 0.00193 | | 0.0007 | 0.0009 | | | |
| Total of hauling operation | $/T.M. | 0.00763 | 0.00814 | 0.0241 | 0.01078 | 0.01135 | 0.0096 | 0.0128 | 0.023 | 0.0791 | 0.0434 |
| Maintenance of | | | | | | | | | | | |
| Haulage units | $/T.M. | 0.01072 | 0.00708 | 0.00745 | 0.00416 | 0.00375 | 0.0014 | 0.0034 | 0.016 | 0.0392 | 0.0190 |
| Sleighs | $/T.M | 0.0026 | 0.00254 | | | 0.0027 | | | | | |
| Overhead | | | | | | | | | | | |
| Supervision | $/T.M. | 0.00174 | 0.00167 | | | 0.00763 | | | | | |
| Head-quarters expenses | $/T.M. | | | | | | | | | | |
| Insurance | $/T.M. | | | | | | | | | | |
| Camps | $/T.M. | | | | | | | | | | |
| Depreciation of equipment | | | | | | | | | | | |
| Interest on capital invested | | | | | | | | | | | |
| General information | | | | | | | | | | | |
| Cost of equipment (new) | $ | | | | | | | | 36,000 | | |
| Haulage units | | 2-5 ton-D Leyland trucks | 2-5 ton-D Leyland trucks | 3-GMC's T 60 5-ton G rebuilt | 5 FWD-G 3½ ton 5 T chassis C U 6-170 in. | 2 Fords 1935 V-8 2-ton G trucks | 2 Internationals 1½-2-ton G | 1 International 1½-2-ton G | 4-G-Leyland 3½ ton trucks 8-10-ton Semi-trailer | 4-2 ton V-8 Fords | 1-2 ton Ford Warford 1-2 ton International |
| Product hauled | | 16 ft. logs | 16 ft. logs | 16 ft. logs | 8 ft. peeled logs | 16 ft. logs | 16 ft. logs | 16 ft. logs | Const. Mat. | Gen'l Supplies | Gen'l Supplies |
| Average number sleighs per train | | 2.8 | 2.93 | 2.5 | 4 | 2.8 | 2.60 | 1.91 | | | |
| Average load per sleigh | tons | 9.65 | 9.29 | 4.5 | 9.2 | 7.15 | 11.70 | 12.60 | Summer | | |
| Average load on haulage unit | tons | 5.23 | 3.91 | | 4 | 1.56 | 3.40 | 3.60 | Operation | 2.5 | 3.52 |
| Average pay load per train | tons | 32.28 | 31.09 | 11.25 | 36.8 | 21.6 | 33.80 | 27.70 | | | |
| Average speed loaded | m.p.h. | | 7 | | 9.44 | 10 | 12.70 | 7.90 | | | |
| Average speed light | m.p.h. | | 14 | | 14.21 | 20 | 14.3 | 11.20 | | | |
| Duration of operation | days | 44 | | 69 | 73 | | 92 | 85 | | All year | Sept.-Feb. |
| Road surface | | Iced | Iced | Iced | Iced | Iced | Iced | Iced | | Gravelled | Gravelled and snow |
| Fuel costs | c. per gal. | 11.25 | 13.3 | 22½ | 22 | 30 | | | | | |
| Wheels on rear axle | | Single | Single | Dual | Single | Dual | Dual | Dual | | | |

Note—Haulage units—If driven by gasoline engine denoted by "G"; if driven by Diesel engine denoted by "D".

In eastern Canada, logs and pulpwood are sometimes loaded directly on trucks for transportation, but owing to the low operating cost of the truck-sleigh train unit, this method is limited to special cases and depends for its success upon the speed of loading and unloading, and upon the character of the road.

To facilitate loading and unloading of pulpwood, an ingenious operator adopted the following scheme.

A rack consisting of two stringers of truck body length, with stakes at both ends, and supported by four hydraulic jacks, is loaded by hand. For loading, the jacks, which are controlled by four men, are lowered, and after loading, the rack is raised to sufficient height to allow the flat deck of a truck to back under the loaded rack and between the stringers. The front stakes of the rack are removed and the rear stakes of the truck replaced. The truck is fitted with a dumping platform. To unload, the rear stakes are removed and the deck tilted up. While the truck is away the rack is reloaded.

Loading on trucks has proved effective where the roads have many sharp curves and steep grades and where it would be impossible to successfully operate a train of sleighs. One such operation transported approximately 30,000 tons of logs, an average of 6½ miles over a very steep and crooked winter road of snow base and iced surface. The average load was approximately 8 tons, which greatly overloaded several of the trucks. The fleet of trucks consisted of Ford Warford 2 ton 157 in. W.B., G.M.C.'s Model T-90-C, International's Model C-40-F, and a Maple Leaf, all but the last equipped with two rear driving axles. The heavier grades against the load were 200 ft. of 13 per cent and 60 ft. of 16 per cent and with the load was a 17 per cent grade for 100 ft. Unfortunately no costs are available from this job.

In British Columbia and the Pacific States, where logging conditions are different to those of eastern Canada, transportation is being performed to an increasing extent by trucks which are displacing the logging railway. An excellent type of road is constructed over which is operated some of the largest trucks and trailers built. These trucks carry up to 50 tons and operate at speeds of 20 to 30 miles per hour.

Attached is a sheet giving the haulage costs, or portion of costs, of several freighting jobs, some done by tractor and some by truck. From the data obtained an endeavour has been made to classify the costs under the usual headings for a haulage operation. This information has been obtained from a number of sources, each of which has its own method of cost accounting and in consequence there may be wide variation. Also, the choice of the conversion unit for logs and cordwood into tons is largely based on judgment, and can only be considered approximately correct. A word of caution is therefore given regarding the use of any of the costs mentioned. It will be noticed that no depreciation of equipment has been shown. This is because nearly every firm depreciated it differently and in a number of cases no value was given.

**Fig. 8—A Ford-Warford Truck hauling a Train of six Sleighs.**

The following are a few cases where freighting has been done by contract—on a per ton, or ton mile basis:

(1) Freighting of 1,600 tons of mining machinery and supplies—a distance of 135 miles of which 117 was over lakes. Eighteen miles of winter road had to be cut. A considerable portion of the lake surface was covered with slush and the general ice condition was such that a 6 or 7 ton tractor was all it could safely carry. The tractors depending upon their capacity hauled 3 to 5 sleighs apiece. Six tons was considered a good load per sleigh. The contract was let for $60 per ton or 44½ cents per ton mile. This year the freighting is being done for 40¾c per ton mile.

(2) Freighting approximately 500 tons of mining supplies a distance of 138 miles over a winter land trail. The rate was 31.1c per ton mile.

(3) Freighting 900 tons miscellaneous mining supplies a distance of 26 miles over an already cut winter road. The rate was 33.7c per ton mile. The loading was contracted for at the rate of 60c per ton, with guaranteed minimum of 15 tons per day. Actual hauling time sixty days.

(4) Freighting 250 miles approximately 500 tons of supplies at a rate of 32c per ton mile. For approximately half of this distance the road is used by other parties.

### Aeroplane Freighting

Aviation has played a very important part in the development of our natural resources, not only in conveying men quickly to remote points, but also in carrying freight.

Last year approximately 13,500 tons of freight were carried by aeroplane and probably by far the greater amount of this was transported to the mines in the north country.

The largest single air freighting job in North America was carried out last year and consisted of transporting 800 tons a distance of approximately 70 miles.

Air rates will vary with the locality owing to changes in the price of gasoline and also with the intensity and type of operation. Aircraft are licensed by the government for a certain "all-up load." The difference between the empty weight and the licensed gross weight is known as the disposable load, and this is in turn divided between operating load and pay load. The former is made up of the weights of the crew, machine equipment, gas and oil; the pay load is the balance remaining after deducting the operating load from the disposable. It will thus be seen that, on operations where extra equipment, extra crew, or when abnormal quantities of gas must be carried, the pay load is correspondingly reduced and the cost per ton mile increased.

**Fig. 9—Logging in British Columbia. Heavy Diesel Truck and Trailer—Load 9,000 f.b.m. (approximately 36 tons). These Trucks handle up to 50 Tons.**

Intensity of flying operations is another important factor. The greatest part of the cost of aircraft operation under present day conditions consists of fixed charges, such as, insurance, depreciation, salaries and overhead. The more hours per month that a machine flies, the smaller are the fixed charges per hour. By having a heavy tonnage available for continuous and rapid handling, it is possible to considerably increase above the average the number of flying hours per month per machine, and thereby decrease the cost per mile flown. This is the reason for the considerable reduction in rates, as the freighting operations progress from occasional work to that of heavy tonnage, as shown by the following figures, kindly compiled by the Canadian Airways Limited. They do not relate to any specific job at present in hand, but are in line with current rates.

Table V

| Distance | 100 miles | 50 miles |
|---|---|---|
| (1) Straight charter basis, cost per trip.. | $100.00 | $60.00 |
| Pay load in pounds | 1,400 lb. | 1,500 lb. |
| (2) As soon as fairly frequent trips are warranted, the operation would be put on a poundage basis. Charges would then be approximately as follows: | | |
| Passengers—per trip | $25.00 | $15.00 |
| Freight per lb. and ton mile | 7c—$1.40 | 4c—$1.60 |
| Maximum charge per trip | $70.00 | $35.00 |
| (3) When traffic in the district became sufficient to warrant establishment of a regular schedule, the following rates could be expected: | | |
| Passengers—per trip | $20.00 | $10.00 |
| Less than plane load lots per lb. and per ton mile | 7c—$1.40 | 4c—$1.60 |
| Plane load lots | 6½c—$1.30 | 3½c—$1.40 |
| (4) On a basis of 500 tons to be available for continuous hauling, the rate per ton mile would be approximately | $1.00 | .90c. |

In certain districts where there is considerable competition, notably about Sioux Lookout or Hudson, the contract rate is 5½c per lb. for 135 miles, or 81½c per ton mile and $1.04 for small quantities. On another job covering about 69 miles, the rate was 94½c per ton mile for a large quantity.

In the undeveloped territories there are several new mines so situated that air freighting is the only practical means of transporting any materials required during the summer. For passenger and mails, it is the only means of transportation.

One of the reasons why aviation is playing such a big part in the development of our hinterlands is the very reason that makes it so hard to build good summer roads—namely, an abundance of water, most of which is in the form of lakes affording an excellent landing in either winter or summer.

Our aviators and the aviation companies are doing a splendid service in furthering the development of our natural resources in a country so difficult of access.

## Conclusions

With the increasing development of our natural resources, and as they extend deeper into the hinterlands, we may look for continued improvement in overland freighting methods. Today, with the adoption of mechanical haulage units, the engineer is playing an increasingly important part in the solution of these freighting problems.

Through the closer co-operation of the manufacturers' engineers with field engineers there is continual development of new equipment, or improving of old, more suited to our northern needs.

Roads are greatly improved and are being located and constructed according to engineering principles, being greatly assisted by aeroplane reconnaissance and surveys.

The telephone, wireless, and aeroplane are important links for the efficient transportation of goods into our undeveloped territories.

The cost of land freighting, whether for summer or winter, depends chiefly on the condition of the roads. Except possibly for small tonnages, the general statement that the better the road the cheaper the overall freighting costs, holds true.

For winter freighting, where there are large tonnages with short hauls, and in some cases, for the longer hauls, or where there is a heavy density of traffic, there is no doubt that trucks will be used to an increasing extent, either as sleigh hauling units, or to carry deck loads, or with semi-trailers.

The tractor, on account of its ability to operate on poor roads, will be used for low density traffic freighting. They haul a heavy load, are good for plowing snow, and general heavy work, and a certain number are a necessity on any winter freighting job. Their slow speed when travelling light is a great disadvantage. Under certain conditions a combination of tractor and truck might be worked out, whereby the tractor on the return trip is loaded on a sleigh and hauled back by truck.

For successful freighting a thoroughly competent and well organized field force is a necessity.

The heavier crawler type of tractor, when equipped with a bull-dozer or road builder, is an excellent machine for clearing and rough grading a road. It can also be used for hauling the heavier grading machines. These methods are helping cheapen the cost of road building.

The aeroplane will always be an important transportation unit for passengers and mail, also for freight, especially where speed is the main consideration.

## Acknowledgments

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## Notes Regarding Cost Units

Example 1—On account large tonnage to be handled, great attention paid to preparing roads over lakes and icing roads on portages. The road was kept in excellent condition during the season.

Example 2—Freighting to same destination as in Example 1. The material freighted consisted largely of heavy machinery, necessitating careful loading and in some cases special sleigh riggings.

The per mile road maintenance is about the same for both years, but the ton mile basis almost double.

Example 3—No break down given for the 12.9c per ton mile hauling operation.

Example 4—The $212 per mile is for 5½ miles of new portages.

Example 5—This example covers 3 winter months haul of a large freighting operation of 42,000 tons and extending over a period of 20 months. The tractor had a body load of 11 tons and hauled a trailer sleigh loaded with a like amount. The maximum grade against the load was 15%.

Example 8—Covers the fuel oil cost for a Diesel operated Linn tractor as compared with the gasoline tractors for the same seasons as Examples 6 and 7.

Example 9—Covers the hauling of supplies to several logging camps, varying from 22 to 52 mile haul. Both tractors are Diesels.

Example 10—Job started late in season—bad road—sharp curves and steep grades.

Examples 11 and 12—Number 11 gives the operating and maintenance costs of best tractor of the 6 included in example 12.

Example 14—Is for an intensive logging operation—operation carried on for 22 hours out of 24.

Examples 15 and 16—Intensive log hauling by same company as No. 14 but haulage unit changed to Diesel Leyland trucks.

Example 18—This company has been operating with the F.W.D. trucks for 5 years and have got their hauling down to a regular system.

Example 22—Is a summer operation over an excellent road.

Example 23—Is a logging company's trucking operations over an entire year and is not comparable to operations 15 to 21.

Example 24—Same logging company as in Example 23. Covering haulage of general supplies during months of September to February—by two trucks.

# Utilization of Electric Power at the Metal and Fertilizer Plants, Trail, B.C.

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**Paper presented before the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June, 1937.**

SUMMARY.—The Trail plant produces lead, zinc, silver, gold, cadmium, bismuth, sulphuric acid and also synthetic ammonia for fertilizer products. There is a continuous electric load of 100,000 kw., supplied to the plant at 60,000 volts and used at 13,200 volts, 2,200 volts and 600 volts. About 75 per cent is converted to d.c. for electrolytic work. Furnace and roaster gases are treated electrically for removal of metallic dust.

The use of electric power plays an important part in the various processes carried out at Trail in the production of metals, chemicals and fertilizer and covers a large field. It is not the purpose of this paper to cover all the problems and details involved, but rather to give a general picture of the layout and operations.

### The Plant

Trail smelter, the largest non-ferrous smelter in the world, is owned and operated by the Consolidated Mining and Smelting Company of Canada. It is located at Trail, British Columbia, on the Columbia river at a point near the International Boundary and is served by the Canadian Pacific Railway by means of a branch line which joins at Castlegar the line running through the Crow's Nest Pass to the coast.

The smelter was first constructed and put into operation in February 1896 by Mr. F. A. Heinze for the purpose of recovering gold from the rich ores in the Rossland area. The original plant had a capacity of 100 tons a day—which was rapidly increased to 250 tons—and covered an area of about two acres. A few years later the smelter was purchased by the Canadian Pacific Railway and with a number of mines in the district was put under the management of the present company in 1906. Lead and silver ores were smelted, but at first zinc could not be handled, in fact lead and silver ores containing over a certain percentage of zinc were penalized, or not accepted, as they interfered with the operations carried out. Eventually as a result of prolonged research, a flotation process of mineral separation was devised whereby lead and zinc in the ore could be separated in the form of concentrates. This, in conjunction with the electrolytic process of plating zinc onto aluminum cathode sheets, solved the problem of treating the complex lead and zinc bearing ores. The production of electrolytic copper was discontinued in 1925. The plant has been greatly enlarged from time to time and new processes added.

Custom ores are treated, but the major portion of the supply comes from the company's Sullivan mine at Kimberley. It is treated in the concentrator there and shipped to Trail in the form of lead and zinc concentrates.

The Trail plant consists of two main sections, the first, Tadanac, where the metal smelter and reduction plants are located as well as the sulphuric acid and $SO_2$ reduction plants, and the second, Warfield, where the various fertilizer departments are located.

The Tadanac plant covers 160 acres with about 30 acres of roofing on buildings. The buildings are nearly all steel with tile, gunite or transite siding. The Warfield plant covers 60 acres and the buildings are nearly all steel and brick. It is located on a higher bench of land about one mile from the Tadanac plant.

The two plants employ about thirty-seven hundred men and the daily capacity for the various products is: lead 550 tons, zinc 400 tons, sulphuric acid 450 tons, fertilizer products 300 to 400 tons, also elemental sulphur. There is

Fig. 1—The Tadanac and Warfield Plants.

a monthly production of approximately 750,000 oz. silver, 27,000 oz. gold, 20 tons of cadmium. Bismuth is recovered from the lead refinery by-products.

### Power Requirements

The power consumption for the year 1936 was 864,-223,827 kw.h. which is the equivalent of a continuous load of practically 100,000 kw. The plants operate twenty-four hours a day and every day in the year. The twenty-four-

**Fig. 2—High Tension Switching Station, Tadanac.**

hour load factor is nearly 95 per cent and the power factor about 95 per cent. For full load production in all departments there is a total load of 125,000 kw. in the plant which is divided approximately as follows:

| | |
|---|---|
| Zinc plant | 47 per cent |
| Chemical and fertilizer | 40 per cent |
| Lead smelting and refining | 8 per cent |
| Balance | 5 per cent |

Of the total 125,000 kw. load for both plants approximately 94,000 kw. is converted to d.c. by means of motor generator sets, rotary converters and mercury arc rectifiers, and is used for electrolytic processes in the production of metals and hydrogen gas. The balance of the power is used for various purposes as required. Except for special cases such as rotary converters and mercury arc rectifiers the general power voltages used in the plant for motors, etc., are 2,200 and 550 volts.

There are 2,612 motors installed having a total of 60,031 h.p. This figure does not include the large motor generator sets, rotary converters or mercury arc rectifiers. For lighting and miscellaneous 110 and 220 volt power requirements in the plant there are 141 transformers installed with a total capacity of 3,430 kva.

It may be of interest to note that before the ore reaches Trail in the form of concentrates from Kimberley the following amounts of electric power have been expended:

| | |
|---|---|
| Mining | 7.5 kw.h. per ton of ore mined. |
| Concentration | 22.2 kw.h. per ton of ore treated. |

### Power Supply

Power for the Trail plants is supplied by the West Kootenay Power and Light Company, a subsidiary company, from its four hydro-electric plants located on the Kootenay river some 30 miles away. These plants have a total installed generator capacity of 179,000 kva. consisting of:

| | |
|---|---|
| No. 1 Plant Lower Bonnington Falls | 52,500 kva. |
| No. 2 Plant Upper Bonnington Falls | 29,000 kva. |
| No. 3 Plant South Slocan | 52,500 kva. |
| No. 4 Plant Corra Linn | 45,000 kva. |

This power is delivered to a central high tension switching station in Tadanac at 60,000 volts, 3-phase, 60 cycles. There are four high tension transmission lines at present but this number is being increased to take care of the larger load which has built up the past few years. The original power supply to Rossland and Trail was at 20,000 volts and consisted of a double circuit line. These circuits were used for the past several years as a standby only but have now been discontinued.

The switching station shown in Fig. 2 is located about midway between Tadanac and Warfield and is equipped with high tension line and feeder oil circuit breakers. It has a duplicate set of main buses and lightning arresters are provided where required. High tension feeders run from this station to the various step-down stations. High tension tie lines are provided between the various step-down stations and are so inter-connected as to form a ring, or loop, which provides an alternative source of high tension power to each station when required.

### Distribution System—60,000 Volt Step-down Stations

There are nine high tension step-down stations, six in Tadanac and three at Warfield. These stations are located in different parts of the plants as near as possible to the load centre of the particular zone to be supplied with power. They are as follows:

*Tadanac Plant*

*No. 1 Sub-station:* Located in zinc plant. Indoor station rated 22,500 kva. consisting of 3 banks of three 2,500-kva. transformers 60,000 to 2,200 volts. The main 2,200-volt bus is carried in a concrete phase isolating structure and supplies twenty feeder circuits of which thirteen are 1,000 kw. motor generator sets.

*No. 2 Sub-station:* Located at refinery. Outdoor type consisting of three 5,000-kva. transformers 60,000 to 2,200

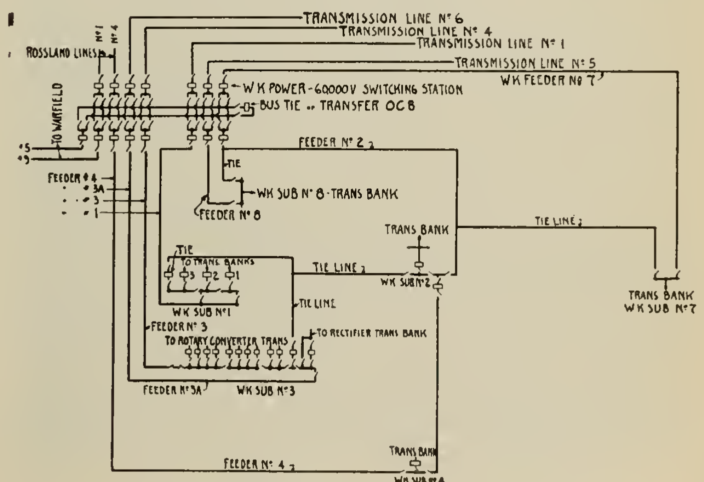



**Fig. 3—60,000-Volt Lines, Feeders and Tie Lines, Tadanac.**

volts. The 2,200-volt power is carried in a tunnel about 150 ft. from the transformers to the lead refinery generator room by means of ten 750,000-c.m. 3-phase P.I.L.C. cables into the distribution bus of a bank of metal clad switchgear consisting of eight feeder breakers.

*No. 3 Sub-station:* Located in zinc plant. Indoor type, rated capacity 51,500 kva. There are eleven 2,600-kva. transformers 3-phase, 60,000 volts to 6-phase 380 volts feeding ten 2,475-kw. rotary converters (one transformer being a spare) (see Fig. 4). Also a bank of three 8,500-kva.

single phase transformers 60,000 to 13,200 volts which feed three 5,600-kw. mercury arc rectifier units.

*No. 4 Sub-station:* Located at lead smelter. Outdoor type, consisting of three 5,000-kva. single-phase transformers 60,000 to 2,300 volts. The 2,300-volt power is distributed through metal clad switchgear to four circuits.

*No. 7 Sub-station:* Located at Stoney Creek pumping station. Outdoor type consisting of three 3,000-kva. single-phase transformers 60,000 to 2,200 volts. There are three 2,200-volt feeder breakers.

*No. 8 Sub-station:* Located at acid and $SO_2$ plants. Outdoor type consisting of three 5,000-kva. single-phase transformers 60,000 to 2,200 volts. There are two 2,200-volt feeder breakers.

*Warfield Plant*

*No. 5 Sub-station:* Supplies 2,200-volt power to the fertilizer plant. Originally this station consisted of three 5,000-kva. single-phase 60,000 to 2,300-volt transformers, but it was found that the insulators became coated with a dust deposit from the phosphate plant nearby which necessitated washing the insulators at frequent intervals. In order to do this without interrupting the service this station was changed to two banks of two 5,000-kva. single-phase transformers in open delta. A third transformer will be added to each bank when load conditions require it. The 2,200-volt power is distributed through metal clad switchgear to four main feeder circuits.

*No. 6 Sub-station:* Located at hydrogen plant. Outdoor type, capacity three 6,500-kw. mercury arc rectifier units, 60,000 to rectifier voltage.

*No. 9 Sub-station:* Located at hydrogen plant. Outdoor type, capacity two 8,300-kw. mercury arc rectifier units, 60,000 to rectifier voltage. A third 8,300-kw. unit is being added this year.

### Distribution System—2,200 to 600 Volt Sub-Stations

Some of the 2,200-volt power supplied by the above step-down stations is used at that voltage and some is stepped down again to supply the large number of 550-volt motors in the plant and also to voltages suitable for electric furnace work and special heating applications.

There are eight 2,200- to 600-volt sub-stations in the two plants. Tie lines are provided to form a 2,200-volt loop, or "secondary ring," such that any of these sub-stations can be fed from its regular step-down station, or if required fed from one of the other stations. The Warfield sub-station is not included in this arrangement, but, as mentioned previously, the step-down station supplying 2,200-volt power at Warfield has two separate banks of transformers.

These eight 2,200- to 600-volt sub-stations are also located in the plants as near as possible to the load centre of the particular zone which they supply and are arranged as follows:

*Smelter:* Old smelter sub-station. Two banks: one 3,000 kva., the other 4,500 kva. The 3,000-kva. bank is quite an old installation and is used chiefly as a standby.
New smelter substation—4,500 kva.
*Refinery:* 2,250 kva.
*Zinc Plant:* 4,500 kva.
*Acid Plant:* 1,200 kva.
*Concentrator:* 1,500 kva.
*Stoney Creek Pumping Station:* 1,500 kva.
*Warfield:* 4,500 kva.

The 600-volt power is distributed through oil circuit breakers to feeders each of which supplies one section of the plant as required.

Power is metered on the main 2,200-volt primary feeder panels and again on the 600-volt secondary feeder panels.

Lighting transformers as far as possible are tapped off the 2,200-volt primary feeders, although in a number of cases the 600-volt feeders are used where the higher voltage is not available.

All 60,000-volt feeders are aerial and in Tadanac the 2,200-volt and 600-volt are also aerial, but at Warfield all the secondary voltage distribution as well as lighting and telephones are carried underground in a duct system.

The present selection of oil circuit breakers for main feeders is based on the following rupturing capacities:

| | |
|---|---|
| 60,000-volt service........... | 1,000,000 to 1,500,000 kva. |
| 2,200-volt service........... | 300,000 kva. |
| 550-volt service........... | 55,000 kva. at 750 volts. |

As a general rule the feeder circuits are limited to the following maximum capacities:

| | |
|---|---|
| 60,000 volts............................. | 25,000 kva. |
| 2,200 volts............................. | 4,500 kva. |
| 550 volts............................. | 1,000 kva. |

A typical 2,200- or 550-volt feeder panel is equipped with the following instruments: watthour meter, indicating wattmeter (for large or important circuits), recording ammeter, one voltmeter per station, induction relays and calibrating studs for current and potential.

As far as possible motor controls in the plant are banked together at distribution centres. Remote, or push button, control for motors is used practically throughout, except for some of the larger and older installations.

Washed air plants are provided for all the generator and rectifier rooms to clean the air before it enters the room and also to cool it in the hot weather period.

### Electrolytic Plants

Approximately 75 per cent of the total power used in the plant is for electrolytic processes for the refining of metals or the production of hydrogen. In order to obtain the direct current required for this class of work three different types of conversion equipment are used, the installed d.c. capacities being:

**Fig. 4—No. 3, H.T. Step-down Station, Zinc Plant.**

| | |
|---|---|
| Motor-generator sets........................ | 18,250 kw. |
| Rotary converters........................ | 24,750 kw. |
| Mercury arc rectifiers........................ | 53,500 kw. |

This d.c. power is distributed in the following manner:

| | |
|---|---|
| Zinc plant............................... | 54,800 kw. |
| Lead refinery............................... | 5,000 kw. |
| Hydrogen plant............................... | 36,700 kw. |

As mentioned previously, another 8,300-kw. mercury arc rectifier is being installed in the hydrogen plant this year; this is not included in the figures just given.

### Zinc Plant

For the production of electrolytic zinc, the zinc arrives in the form of concentrates. These concentrates are roasted in the concentrate burning furnaces to drive off sulphur, then the zinc is put into solution in the leaching plant by dissolving it in acid, and after this solution is purified it is pumped to large storage tanks. From these tanks it is pumped to the electrolytic tank rooms where the zinc is plated on aluminum cathode sheets from which it is stripped every twenty-four hours, sent to the melting room to be melted down, and cast into 56-lb. bars for shipping. Some of the zinc is recovered at the lead smelter in the slag retreatment plant in the form of zinc oxide. This zinc oxide is dissolved and purified in a separate leaching plant from the roasted zinc concentrates and is then fed to the electrolytic tanks.

**Fig. 5—Zinc Refinery, Electrolytic Tank Room.**

The older electrolytic tanks are reinforced concrete tanks with a lining of rubber. All new tanks are now being made from Prodorite, which is an asphalt base material mixed with sand and crushed rock. These tanks are made up in the form of a double tank and are arranged for gravity flow of the solution and are connected electrically in series. The anodes are made of lead and are permanently attached in parallel to a copper bus bar which is lead covered and runs on one side at the top of the tank. The aluminum cathodes have two lugs attached at the top, one copper and one iron. The copper lugs make contact with the copper cathode bus also on the top of the tank, and the iron lugs rest on, but are insulated from, the anode bus. These cathodes are pulled out of the tanks one at a time while the unit is on load. The zinc is stripped off and the cathode replaced. The number of cathodes in a cell varies from 16 to 23 depending on the current density used. The size of the immersed area of the cathode is 2 ft. by 2 ft. 6 in. or ten square feet per cathode since both sides are used. There is always one more anode than cathode. The spacing is 3 or 4 in. depending on the number of cathodes per cell.

The maximum current density used is 52 amp. per sq. ft. For a current density of 40 amp. per sq. ft. the voltage per cell is approximately 3.5 volts which is made up as follows:

| | |
|---|---|
| Theoretical decomposition voltage of zinc sulphate ($ZnSO_4$) | 2.56 volts |
| Anode and cathode voltage plus polarization | 0.42 volts |
| Potential drop due to resistance of electrolyte | 0.52 volts |
| Total | 3.50 volts |

The cell efficiency obtained is 91-92 per cent.

The power consumed in producing one pound of electrolytic zinc is 1.62 kw.h.

### Direct Current Supply

In 1916-17 when the zinc plant first went into operation thirteen 1,000-kw. 125-volt motor generator sets were used. These sets have two 500-kw. generators, each of which supplies a group of 36 zinc cells with 4,000 amp. These generators are direct connected to a 2,200-volt motor.

When extensions were made to the zinc plant in 1925 and 1927, ten 2,475-kw. rotary converters were installed having a voltage range 470-550 volts. These machines are booster type with a.c. starting. They are fed from a 60,000-volt bus through individual transformers. Originally each rotary operated its own tank unit of 144 cells at 4,500 amp., but later it was decided to operate two rotaries in parallel at 9,000 amp. on each tank unit. Eight rotaries are now operated this way, one still operates singly on its tank group and one is used as a spare. Electrical interlocks on the d.c. side are provided for the units operating in parallel to protect these machines from severe overloads in case one unit drops off load.

A 10,000-amp. paralleling bus is run in the basement under the rotaries so that any group of machines can pick up any tank unit desired. This bus extends into the mercury arc rectifier section of the room.

In 1929 the zinc plant was extended again and this time three 5,600-kw. 10,000-amp. mercury arc rectifiers with d.c. voltage range of 460-560 volts were installed. Rectifiers at this time were coming into prominence in electric railway work as well as d.c. networks in cities and from their performance on these loads gave indications of being suitable also for electrolytic work, although few installations of any size were in operation at that time. It was found that, just as in the case of motor generator sets and rotary converters when they were first used for electrolytic work in various parts of the world, changes were necessary in the original rectifiers supplied in order to carry full load. These units have been operating at 9,000 amp. satisfactorily for some time now.


**Fig. 6—Rotary Converters, and Mercury Arc Rectifiers, Zinc Plant.**

The rectifiers are fed from a 13,200-volt bus in No. 3 step-down station and the d.c. voltage range of 460-560 is made in 24 steps by means of taps on the high tension winding of the rectifier transformers and an "on load" tap switch. There are two 5,000-amp. twelve anode cylinders (double six phase) per unit operating in parallel from one transformer. Air type reactors are provided on the d.c. side to smooth out the ripples. Closed circuit rectifier cooling, high speed d.c. circuit breakers and grid control for backfire or short circuit suppression are installed.

The power is metered on the high tension side of the rectifier transformer. Auxiliary 3-phase 110-volt power used for the rectifier is supplied by three 25-kva. oil insulated self cooled single-phase transformers fed from the 13,200-volt bus.

Fig. 7—Lead Refinery, Electrolytic Tank Room.

## Operating Data

The efficiencies of the various types of conversion equipment used in the zinc plant are:

| | |
|---|---|
| Motor generator sets | 86 per cent |
| Rotary converters | 96 per cent |
| Mercury arc rectifiers (including 1.3 per cent loss in the rectifier transformer) | 93.5 per cent |

The observed power factor of the rectifiers measured on the 13.2-kv. bus is 92.25 per cent. The motor generator sets and rotary converters operate at unity power factor.

A comparison of the percentage of time lost on these various units due to changes, maintenance and repairs to the total possible operating time for 1935 and 1936 is:

| | 1935 | 1936 |
|---|---|---|
| Motor generator sets | 5.55 per cent | 4.3 per cent |
| Rotaries | 7.08 per cent | 2.83 per cent |
| Rectifiers | 6.07 per cent | 1.1 per cent |

Outages for tank room or other causes are not included in the above figures. It should be noted also that the above outages do not necessarily mean loss of production in the plant, because quite a large percentage of the above time is made up from work done, such as complete general overhauls, etc., when the machines are down for other reasons. Also in No. 3 generator room there is one spare rotary converter which is used when one of the other units is off load for overhaul or repair.

## Lead Smelter and Refinery

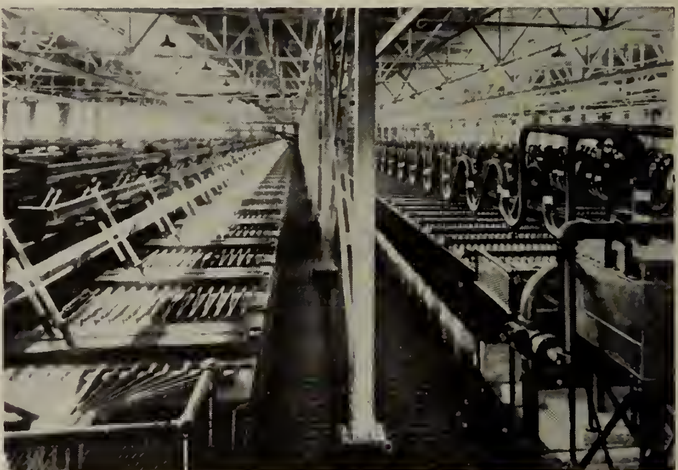
The bulk of the lead arrives in the form of concentrates which are mixed with flue dust and other ingredients, then "sintered" on Dwight and Lloyd machines to drive off the sulphur and some of the other impurities. After a double sintering process the sinter cake is fed to the lead blast furnaces along with various fluxes and coke. The metallic lead is tapped from the furnaces and taken to the drossing plant, where the dross is skimmed off and the lead cast in the form of anodes weighing about 370 pounds each, which are taken to the refinery and placed in the electrolytic tanks. The pure lead is plated onto lead starting sheets and every three days these are pulled, melted down and cast into 100-lb. pigs ready for shipping. The lead anodes are changed every six days.

Gold, silver and other metals are recovered from the slimes, or deposit left in the tanks after the lead has been plated out.

The electrolytic tanks are asphalt-lined reinforced-concrete tanks made up in the form of a double tank (see Fig. 7). These tanks are arranged for gravity flow of the electrolyte and are connected electrically in series. The lead anodes come from the drossing plant as mentioned above, and the cathodes or starting sheets are made from pure lead in the form of a thin sheet suspended from a copper bar. The cathodes are spaced 4⅛ in. apart. For 4,000-amp. operation there are 20 anodes and 21 cathodes. For 5,000 amp. there are 24 anodes and 25 cathodes. The area of the immersed section of each anode (both sides) is 11.8 sq. ft. The approximate current density is 17 amp. per sq. ft. The anodes and cathodes in each cell are connected in parallel respectively and in pulling the cathodes or anodes short circuiting bars are put across the bus bars on each end of the tanks thus cutting out this cell and then all the cathodes are pulled at one time by means of a crane. The voltage per cell is approximately 0.5 volts. The number of cells per unit varies from 240 to 300.

| | |
|---|---|
| The cell efficiency is | 90-93 per cent |
| Pounds of lead per kw.h | 10-12 |

To supply these electrolytic cells there are six motor generator sets consisting of one 1,200-kw. set 200 volts,



Figs. 8 and 9—Hydrogen Plant, Cell Rooms, Warfield.

three 1,000-kw. sets 200 volts, one 500-kw. set 120 volts and one 400-kw. set 110 volts. These last two sets are now used chiefly as spares. Bus bars are arranged to pick up the load on the spare machine if one of the other sets is down.

## Chemical and Fertilizer Plants

The company had been considering the question of utilizing the smoke from the zinc plant and lead smelter for some time and in 1929 started the construction of plants for this purpose. Smoke from the zinc plant was first to be used but a plant is now being constructed to treat the smelter smoke. A small sulphuric acid plant using the contact process was already in operation and three more plants of large capacity were built. At Warfield, where the acid is used in the production of fertilizer, the following were erected and put into operation, namely, hydrogen plant ammonia plant, phosphate plant and ammonia sulphate plant, as well as suitable storage bins, etc.

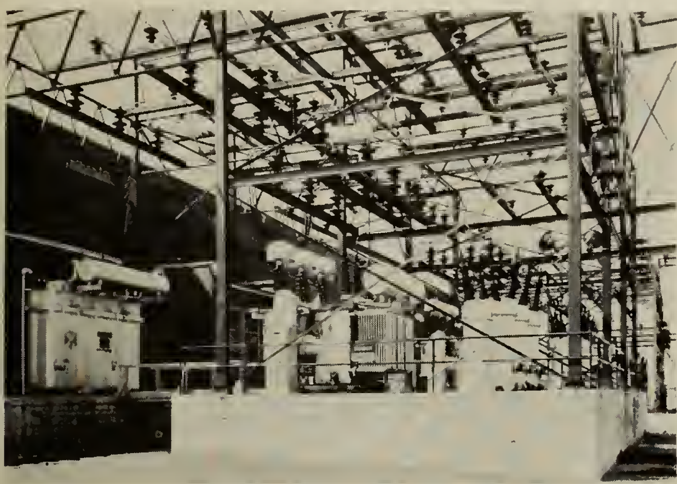


**Fig. 10—Hydrogen Plant, Rectifier Sub-station, Warfield.**

Of the total power used in these plants the hydrogen plant consumes approximately 80 per cent, ammonia plant 8 per cent and acid plant 6 per cent, the balance being distributed to other parts of the plant as required.

### Hydrogen Plant

Hydrogen is obtained by means of the electrolytic decomposition of water. In the original installation there were four types of cells used, namely, 306 Knowles (41 electrodes per cell), 312 Fauser (31 electrodes), 14 sections of Pechkranz and 24 Stuart. These cells were assembled into three 10,000-amp. 650-volt units.

Early in 1936 two more units of 360 Fauser cells (21 electrodes) were added. These operate at 10,000 amp. 830 volts. Another 10,000-amp. 830-volt unit is being installed this year which will consist of 336 Fauser cells (15 electrodes), while the original 312 Fauser unit is being changed to 270 cells (15 electrodes) but will still operate at 10,000 amp. 650 volts.

The majority of cells now installed are the Fauser type. They consist of a number of sheet iron electrodes suspended in an iron tank which is supported on porcelain insulators (see Fig. 8). The electrolyte used is either sodium hydroxide (NaOH) solution or potassium hydroxide (KOH). The electrodes are encased in an asbestos bag which traps the gas given off, it then enters a collector chamber at the top of the electrode and is fed into the gas mains by means of an insulating glass tube. The gas mains themselves are in sections insulated from each other at various points. Oxygen is collected at the anodes and hydrogen at the cathodes, there always being one more cathode than anode. The anodes are nickel-plated to protect the iron and also because the oxygen over-voltage to nickel is less than to iron. The cathodes are not plated. Provision is made automatically to keep the level of the electrolyte in the cell constant by feeding in distilled water, also means are provided for cooling the cells.

The cells are connected electrically in series. The current densities used vary from 36 amp. per sq. ft. for the 31 electrode cells to 67 amp. per sq. ft. for the 15 electrode cells. The voltage drop per cell also varies between 2 and 2.4 volts, depending on the current density used and the operating temperature of the cells, etc.

The Knowles and Stuart cells resemble the Fauser, but the Pechkranz cells are of the filter press type and operate in two groups in series, each group consisting of seven sections in parallel.

D.c. power for the above cell units is obtained by means of five mercury arc rectifiers; a sixth is being installed this year to feed the new cells. These are all 10,000-amp. units with two 5,000-amp. cylinders in parallel operating from one transformer. Three of the units are 600 to 670 volts d.c. and two 740 to 830 volts. The new unit will be 740 to 830 volts also. One of the 670-volt units is twelve-phase but all the others are double six phase and use d.c. reactors to smooth out the ripples.

The general arrangement of equipment is somewhat similar to the zinc plant layout, except that the transformers are outdoors, also there is a single step-down from 60,000 to rectifier voltage. The d.c. voltage range is obtained by means of voltage regulating transformers on the high tension bus just ahead of the main rectifier transformer. Each rectifier operates its own cell units and they are all operating satisfactorily at continuous full load.

A comparison of the percentage of time lost on these units due to changes, maintenance and repairs to the total possible operating time for 1935 and 1936 is:

| | |
|---|---|
| 1935 | 0.62 per cent |
| 1936 | 1.84 per cent |

The increase of lost time in 1936 was due largely to certain adjustments and changes made in the two new units put into operation early in the year. These figures do not include lost time due to tank room or other causes.

### Ammonia Plant

Ammonia is produced by combining hydrogen and nitrogen gas in a catalyst column under high pressure and at a high temperature. The nitrogen is produced by "boiling off" from liquid air. There are two units in this plant each capable of producing over forty tons of anhydrous ammonia a day (see Fig. 11). In the liquid air section a Burckhardt compressor is direct connected to a 450-hp. synchronous motor. The mixed gases are compressed by means of six-stage compressors which are driven by 2,250-hp. synchronous motors. Heaters on the four catalyst and one pre-catalyst columns are supplied by five 250-kva. transformers which have tap switches and a secondary

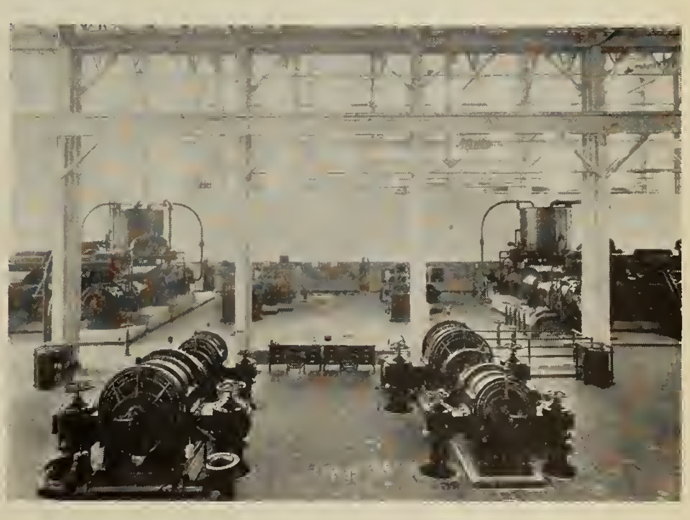


**Fig. 11—Ammonia Plant, Warfield.**

voltage range of 50 to 220 volts. There are four 125-hp. Breda gas circulating pumps as well as other smaller equipment installed.

The above descriptions cover the processes which consume the major portion of power used in the plant. Other processes in operation are relatively small consumers of power and will not be described, there are however a number of applications which while not involving large blocks of power may be of interest, a few of which are:—

### Dust Precipitation

There are several Cottrell treaters in the plant, used for the precipitation of metallic dust from the furnace and roaster gases on their way to the flue, as well as a "mist" precipitator in the acid plant.

The process requires a high potential uni-directional current at approximately 40,000 to 50,000 volts, which sets up an electrostatic field around wires which are suspended between metallic plates, or in some special cases are suspended in metal pipes.

Mechanical rectifiers are used to obtain this current. Some of the sets have the discs mounted on the same shaft as a small a.c. generator which supplies power to a transformer where it is stepped up to the required voltage. In others the disc is driven by a small synchronous motor while the 550-volt supply is stepped up by transformers. These sets are 25 kva. and several are used to supply a smoke treater which is divided into sections.

### Refinery Electric Evaporators

In the silver and gold refinery electric heating is used to evaporate solution for the recovery of blue-stone (copper sulphate). This is done by immersing electodes in two open type tanks of solution which are connected by having a small flow of solution between the tanks. This restricted area of solution makes a moderately high resistance path for the current flowing and is heated in this manner. These units are fed by 100-kva. transformers 2,200 to 110 volts.

The boiling point of the solution to be evaporated is 112 deg. C. If low pressure steam were used for this work the latent heat of evaporation could not be utilized, but only a small amount of the heat value above this point, which would give poor efficiency. The efficiency of the electric evaporation is about 85 per cent.

### Electric Steam Boilers

Three 1,500-kw., 2,200-volt, 3-phase electric steam boilers are installed at the refinery. They are placed together in a suitable location and feed steam into a common main for use in the plant to supplement the steam supplied from the waste heat boilers at the slag retreatment plant. These are used only intermittently.

### Electric Steel Furnace

A three-ton Greene electric steel furnace is used in the foundry for making steel and iron castings. Three 750-kva., 2,200/80-160-volt transformers are used and automatic control provided. The furnace operates at a little over 1,000 kw., taking about three hours for a full charge.

### Pumping Stations

The Stoney Creek pumping station pumps water from the Columbia river to a million gallon reservoir on the side of the hill above the Tadanac plant. It works against 400-ft. head and has a capacity of 38,000 gal. per min. with 5,775 installed horse power.

To supply the Warfield plant a second set of pumps is installed at the reservoir. The head is 517 ft. and capacity 15,000 gal. per min. with installed horse power of 3,050.

### Zinc Plant Bluepowder Electric Furnace

A ten-ton electric furnace for the production of zinc dust (bluepowder) from dross is used in the zinc plant, supplied by three 500-kva. 2,200/40-90 volts transformers. This furnace also has automatic control.

### Traction System, Cranes and Shops

The Tadanac plant is served by an 18-in. narrow gauge trolley system operating at 250 volts d.c. There are fifty-two 4- and 6-ton locomotives. Vee cars are used for transporting concentrates and similar materials, while special cars in the form of racks are used for carrying lead anodes; flat cars are used for general haulage.

A 500-kw. rotary converter supplies power to the system through feeders. Two 200-kw. motor generator sets are used as a standby.

The Warfield plant has no electric traction system, all the transportation of material being handled by motor trucks or conveyors. Warfield is also served by the Canadian Pacific Railway for shipping and heavy haulage.

There are over ninety hoists and cranes of different sizes in the plants. Some are 550 volts, 3-phase a.c. and others 250 and 125 volts d.c.

There are shops covering all kinds of work to be done in the plant. These are well equipped to handle any repair jobs which come up, as well as to make a large assortment of replacement parts and in some cases part of the equipment used in the plant.

# Modern Motive Power

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada in June 1937, in Montreal.**

**SUMMARY.—The author sketches the evolution of the various passenger and freight locomotive types, gives notes on modern light locomotives and trains, discusses the Diesel locomotive as applied to passenger and switching service, and is of opinion that the steam locomotive will predominate for some time to come in main line service on Canadian railways.**

It is fitting, as an introduction to a subject which so vitally influences our social, business and financial life, as does safe and rapid transportation, that we should, in the first instance, consider the evolution of the steam locomotive since its inception.

In particular, we may recall some of the steps by which the crude device which emerged upon the roads of France in 1769 became the present high speed, high capacity streamlined locomotive of to-day.

Despite the development of internal combustion engines, and their introduction into railway power units, the steam locomotive, with its flexibility, high capacity and ability to operate at high speeds, still holds as securely as ever the esteem which led every boy to wish to run a locomotive and every man to hear, in the musical note of an engine whistle, an invitation to seek surcease from his burdens by travel.

### Development of The Steam Locomotive

The first locomotive to actually operate by steam power over rails was built in 1803 by Richard Trevithick. Imagine the satisfaction of the builder when, hauling nine tons of iron, this locomotive attained a speed of five miles per hour. This machine definitely determined the two elementary facts which made to-day's locomotive possible; that sufficient adhesion for traction could be obtained by the use of smooth rails and smooth wheel treads, and that sufficient draft for maintaining steam pressures could be obtained by forcing exhaust steam from the cylinders through the smoke stack.

Early landmarks in the development of the locomotive were Hedley's "Puffing Billy" in 1813, with its complication of connecting rods, walking beams and gears; Blenkinsop's locomotive of 1814; several designs by Stephenson from 1815 to 1829, and in the latter year, the "Rocket." The successful performance of this locomotive upon the Liverpool & Manchester Railway led to the modern engine of to-day.

The first locomotive to be used in America was the "Stourbridge Lion" built in England for the Delaware & Hudson Canal Company. It arrived in America in 1829, making its initial trip at Honesdale, Pa., August 8th, 1829. The total weight of this engine was seven tons. Parts of the machinery and the boiler have been preserved in the National Museum, Washington, D.C.

In 1831 commenced the construction of several locomotives in the United States, including such well known engines as the "John Bull" of the Camden & Amboy; the "West Point" of the Charleston & Hamburgh; the "Dewitt Clinton" of the New York Central & Hudson River; the "York" of the Baltimore & Ohio.

The following year, 1832, saw the introduction of a four wheeled engine truck, embodied in the "Experiment" of the Mohawk & Hudson Railroad; also Baldwin's "Old Ironsides," the first successful locomotive built in America, was constructed.

### Evolution of Passenger Locomotive Types

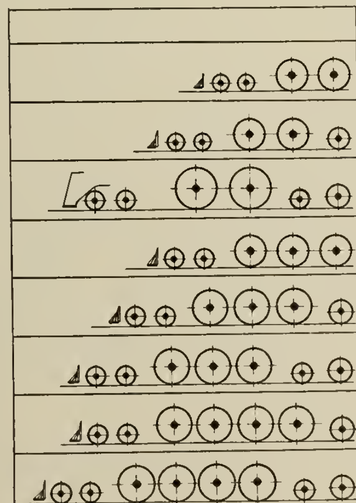
A type of locomotive which became almost universal upon American railroads was introduced in 1837 by Henry Brooks of Philadelphia. It had a four wheeled leading engine truck, horizontal cylinders, two pairs of coupled driving wheels and a tender for fuel and water. This wheel arrangement became known as the 4-4-0 or "American" type and was in general use in the United States and Canada for many years. Improved through the years, this type reached its peak performance on May 10th, 1893, when engine number 999 of the New York Central & Hudson River Railroad was credited with a speed of 112.5 miles per hour, while hauling the Empire State Express. This locomotive had cylinders 19 in. by 24 in., 86 in. dia. driving wheels, a boiler pressure of 180 lb. per sq. in., and a weight of sixty-two tons. The speed made by this little engine over the light track of the day has set a mark seldom exceeded even by modern motive power of any kind.

America was not alone in its appreciation of the 4-4-0 type locomotive. For many years the Midland Railway of England utilized this type of engine for most of their passenger train service.

At the present time, the "City" and "County" classes of the Great Western, the "Shire" class of the London and North Eastern and the "Schools" class of the Southern bear daily testimony upon English railways to the excellent qualities of engines using this wheel arrangement.

The evolution of various other wheel arrangements from this basic arrangement, by the introduction of additional driving wheels, of two-wheeled trailing trucks and more recently, of four-wheeled trailing trucks, is depicted by Fig. 1.

In 1895 the Baldwin Locomotive Works, Philadelphia, designed the first "Atlantic" or 4-4-2 type locomotive, by



| WHEEL ARR'G'T. | NAME OF TYPE | YEAR |
|---|---|---|
| 4-4-0 | AMERICAN | 1837 |
| 4-4-2 | ATLANTIC | 1895 |
| 4-4-4 | JUBILEE | 1935 |
| 4-6-0 | TEN WHEEL | 1847 |
| 4-6-2 | PACIFIC | 1901 |
| 4-6-4 | HUDSON | 1926 |
| 4-8-2 | MOUNTAIN | 1912 |
| 4-8-4 | NORTHERN | 1926 |

**Fig. 1—Development of Passenger Locomotives.**

adding a two-wheel trailing truck to the wheel arrangement of the 4-4-0 type. On account of its greater boiler capacity, better riding qualities and superior operation at high speeds, the Atlantic type superseded the American type for handling main line passenger service. To-day, relegated to local or branch line service, a few survivors still give satisfactory service.

Notable examples of the Atlantic type locomotive were engine 1027 of the Atlantic City Railroad, which made consistent records of speed and reliability between Camden and Atlantic City; the high wheeled Brooks engines of the Central Railroad of New Jersey; the 2900 class of the New York Central and others on the Harriman Lines, the Erie, the Burlington, Baltimore & Ohio and Mid-Western Lines. Some popular examples of compound locomotives were of this type.

In Canada at the turn of the century, on the Canada Atlantic Railway and Canadian Pacific Railway, the performance of the Atlantic type engines added to the laurels already earned, by records made in high speed passenger service between Montreal and Ottawa. A brief description of the locomotives built by the Canadian Pacific Railway Company at Montreal, in 1899 may be of interest. They had Vauclain compound cylinders of the following dimensions: cylinders, high pressure 13½ in. dia., low pressure 23 in. dia., stroke 26 in., boiler pressure 200 lb. per sq. in., diameter of driving wheels 84 in., tractive effort 18,000 lb. Weight of engine and tender—138 tons.

Successful examples of 4-4-2 Atlantic type engines also had an important place in the movement of passenger trains in England on such representative lines as the Great Northern, North Eastern, North British, Great Central and other railways.

It is a remarkable tribute to the Atlantic type locomotive that recent designs of locomotives for high speed passenger operation are based upon the 4-4-2 type locomotive, in some cases modified by the application of a four wheeled trailer truck.

In the design of the "Lady Baltimore" of the Baltimore & Ohio; of the "Hiawatha" of the Milwaukee, and of the "Jubilee" type of the Canadian Pacific, the experience accumulated in forty years operation of these successful locomotives has served as a foundation for the development of a most satisfactory new type of passenger motive power for the movement of light weight high speed trains. When the increasing weight of trains created a demand for more powerful locomotives, the adoption of new types followed. The ten-wheeled locomotive, evolved by adding an additional driving wheel to the 4-4-0 American type engine, was first built in 1847 by Septimus Morris.

The first Jubilee type locomotives on the Canadian Pacific were built for high speed operation and the 4-4-4 type was selected in preference to the 4-4-2, one of the principal reasons being to keep down the track stresses. The 4-4-2 type, with heavy wheel loads, would have given track stresses the equivalent of our heaviest type locomotives due to the wheel spacing. This year, when it was decided to build additional light weight equipment for operation on branch lines, it was necessary to modify the wheel arrangement slightly from the original Jubilee type This was arranged for by connecting the main rod to the rear driving wheel instead of the front driving wheel, thus allowing the driving wheels to be moved forward and decreasing the spacing between the leading engine truck and the leading driving wheel.

Notable speed records were made by high wheeled locomotives of the 4-6-0 type on the Lake Shore & Michigan Southern (now New York Central); on the "Royal Blue" trains of the Baltimore & Ohio and on other American railroads. The next phase of the progress of the ten wheeled type was the addition of a two wheeled trailing truck, thus bringing into existence the 4-6-2 "Pacific" type.

The first locomotive with this wheel arrangement was built in 1901 for the New Zealand Government Railways. The first group to be given the type name was built in 1903 for the Missouri Pacific from which the name originated. Many successful designs followed, until most of the main line trains of the United States and Canada were headed by Pacific type engines.

The Canadian Pacific, in 1906, built two groups, later extended by two more designs, all of which have produced most satisfactory records for efficiency and reliability. At the present time the Canadian Pacific operates 259 Pacific type locomotives in passenger and fast freight service.

The next development was the installation of a four-wheeled trailing truck, which, known as the 4-6-4 or "Hudson" type, has become very popular for high speed train handling. The best known early locomotives, from which the name was derived, were the 5200 class on the New York Central Railroad. Canadians are familiar with the 2800 class of the Canadian Pacific, and the 5700 class of the Canadian National, both of which are most efficient in meeting the difficult conditions of present day travel. The Hudson type possesses ample boiler capacity to ensure the maintenance of high sustained horsepower, large diameter driving wheels to permit of travelling at high speeds, and good riding and guiding qualities.

The addition of another driving wheel to the Pacific type, as first introduced by the Chesapeake & Ohio in 1912, resulted in a new arrangement, the 4-8-2 "Mountain" type locomotive. This was especially suited to the movement of heavy main line passenger trains and is also used to a considerable extent for fast freight work.

Canada was not behind in realizing the advantages of the type and in the same year, the Canadian Pacific built two Mountain type locomotives. The 6000 class of the Canadian National are of this wheel arrangement.

The four-wheeled trailing truck having proved its desirability, its inclusion in the place of the two-wheeled truck followed and thus was derived the 4-8-4 or "Northern" type. Built first in 1926, the 4-8-4 has become deservedly popular for heavy passenger and fast freight work. Canadian examples are the well known 3100 class of the Canadian Pacific and the 6100 class of the Canadian National.

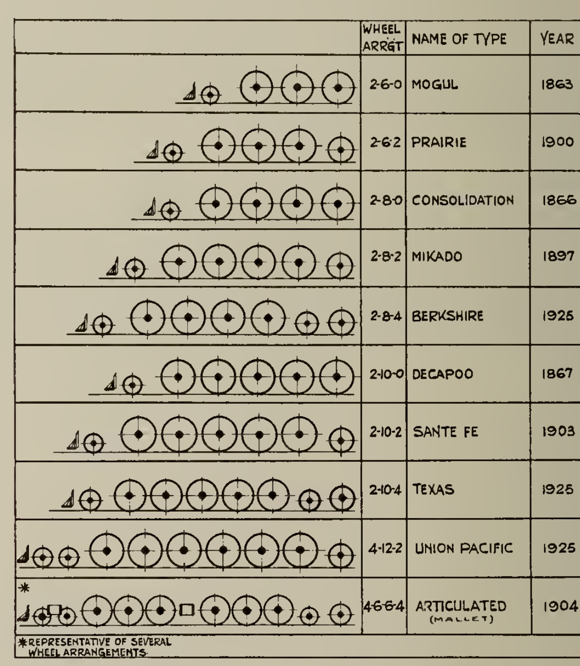



Fig. 2—Development of Freight Locomotives.

### Evolution of Freight Locomotive Types

The development of the types of freight locomotives was similar to that of passenger locomotives. In 1863, the 2-6-0 or "Mogul" type was introduced. It had such a popular appeal that even to-day the type name is wrongly used to signify a large massive locomotive. From this, the next step was the 2-6-2 and then the 2-8-2, and so on, up to the 4-12-2 used on the Union Pacific, as shown in Fig. 2. Figure 2 does not include the 4-14-4 type constructed for the Russian government in 1935, of which very little information regarding performance is available.

The story of the evolution of steam locomotive types is not complete without reference to the articulated type engine, where two complete engines are used under a single boiler to develop large tractive effort. This type of locomotive is used in both passenger and freight service, particularly in mountainous territory.

### Details of Steam Locomotive Construction

*Boiler:*

Locomotive boilers have changed considerably since the early days of the locomotive. Not only have they increased greatly in size, and in pressures used, but such auxiliaries as superheaters, brick arches, feedwater heaters and combustion chambers are practically standard on modern power. Alloy steels are now being used extensively in locomotive boilers, following the introduction of nickel steel boiler barrels by the Canadian Pacific on a comparatively large number of engines in 1926.

The following tabulation (see Table I), comparing the dimensions of early and recent boilers of Canadian Pacific locomotives may be of interest.

Table I

Boiler Dimensions

| | | | |
|---|---|---|---|
| Type of locomotive | 4-4-0 | 4-4-4 | 2-10-4* |
| Date built | 1882 | 1936 | 1929 |
| Tractive effort—lb | 13,160 | 26,500 | 89,200 |
| Boiler pressure—lb | 140 | 300 | 275 |
| Firebox, length | 5 ft. 11-13/16 in. | 9 ft. 6-1/16 in. | 11 ft. 8-3/16 in. |
| Firebox, width | 2 ft. 11 in. | 5 ft. 10-3/16 in. | 8 ft. 0 in. |
| Grate Area sq. ft | 17.4 | 55.6 | 93.5 |
| No. and dia. of tubes | 159-2 in. | 47-2¼ in. | 59-2¼ in. |
| No. and dia. of flues | Nil | 120-3½ in. | 203-3½ in. |
| Length of tubes and flues | 11 ft. 1¾ in. | 18 ft. 10-13/16 in. | 20 ft. 4⅞ in. |
| Superheater | Nil | With | With |
| Tube and flue heating surface—sq. ft | 928 | 2601 | 4509 |
| Arch tube heating surface—sq.ft. | Nil | 34 | 45 |
| Firebox heating surface—sq. ft. | 113 | 198 | 377 |
| Superheating heating surface—sq. ft | Nil | 1100 | 2112 |
| Combined heating surface—sq.ft. | 1041 | 3933 | 7043 |

*The boiler of the 2-10-4 class represents one of the largest boilers now in service on Canadian Pacific Railway locomotives operating in the Canadian Rockies.

There have been numerous experiments in boiler design with a view to utilizing higher steam pressures and eliminating stayed surfaces. Boilers with water tube fireboxes have had many sponsors, from the early designs of Brotan in France, to the multi-pressure designs of recent years. A few of these are still in service. Their comparative complication and maintenance difficulties have prevented their general adoption, although they have shown economies in operation.

At the present time the Union Pacific has under construction a turbo-electric steam locomotive with a novel type of automatic steam generator of the water tube design. This locomotive is to have two steam generating units; a capacity of 4,800 h.p., and a steam output of 40,000 lb. per hr. at 1,500 lb. pressure.

*Cylinders, Valves:*

The cast iron slide valve cylinders of early locomotives have been replaced by cast steel piston valve cylinders made either in halves, bolted together, or integrally cast with the engine bed or frame. The inside Stephenson valve motion has been superseded by outside, accessible motions of the Walschaert, Baker or Southern type.

For reversing the locomotives, screw and air operated gears are standard practice.

*Frames, Trucks, etc.:*

Modern locomotive frames are of cast steel, in one piece, including front bumper, cylinders, cross bracing, firebox supports, motion bearers and brackets for air pumps, brake hangers, etc. The trucks are of cast steel, usually equipped with roller bearings.

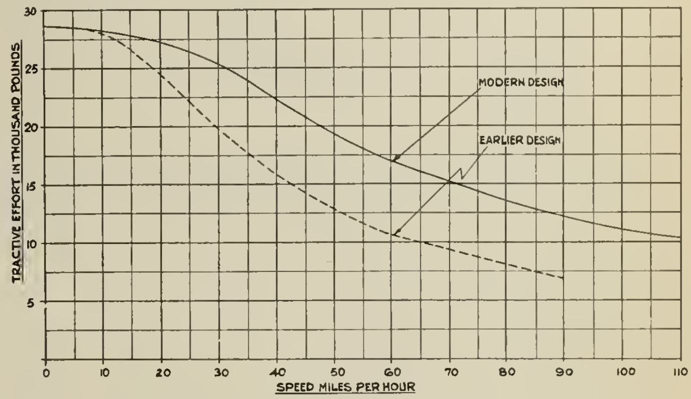



**Fig. 3—Speed-Tractive Effort Curves, Passenger Locomotives.**

Improved types of driving axle boxes reduce maintenance and permit less slack and wear to develop.

*Machinery, Rods:*

The use of alloy steels for valve motion parts and rods is general. By their use the weight of the details is decreased and difficulties encountered at high speeds materially reduced.

*Draft Appliances:*

Constant study and experimental work is being conducted with regard to draft appliances, not only by individual railway companies but also by committees of the Association of American Railroads. The result has been a steady improvement in fuel consumption. The record of Canadian railways in respect to fuel consumption has been most encouraging.

*Special Devices:*

The modern locomotive has many accessories which were unknown to locomotives of past years.

The superheater, which takes from the flue gases sufficient heat to raise the steam temperature to 700 deg. F. or higher, is standard practice to-day and is indeed the heart of the modern locomotive.

Feedwater heaters, deriving heat from a portion of the exhaust steam, raise the temperature of the feedwater before it enters the boiler, thus reducing fuel required and lessening boiler maintenance.

On account of the increase in firebox dimensions, stokers are applied to all large locomotives. It may be noted, in passing, that the type of stoker now in most general use, was first used in Canada on the Canadian Pacific Railway.

Small engines, known as boosters, increase the starting tractive effort of the locomotive by furnishing driving power to one of the trailing truck axles.

Lubrication of valves and cylinders is principally mechanical, while driving boxes, connecting rods and machinery use grease for lubrication.

Tender coal and water capacities have been increased to eliminate frequent stops for supply, and devices to improve the quality of water supplied to the boiler have been installed.

The changes which have been made in the steam locomotive over the past ten to twenty years have resulted in the production of a locomotive having a higher sustained capacity over a greater range of speed. Figure 3 shows the tractive effort curve of two locomotives having the same equivalent starting tractive effort, one for an early type locomotive and one of present day construction. It will be noted that in the older locomotive, the tractive effort drops off rapidly over the higher ranges of speed as compared to that of the modern locomotive. This accounts for the fact that the locomotive of to-day, if it can start the train satisfactorily, can handle a greater number of cars at higher rates of speed than the older locomotives.

### Modern Steam Locomotives and Trains

*Light Locomotives:*

Development of light weight trains powered by oil electric equipment has been paralleled by similar activities in the design of efficient high capacity steam locomotives specially purposed to operate in conjunction with trains of conventional type, but so constructed that the weight of the cars approximates 40 per cent less than that of cars previously considered standard. Such locomotives have demonstrated their ability to maintain schedules as fast as those operated by oil-electric units; have been more reasonable in initial cost; permit of flexibility in making up consist of trains; may be maintained by existing shop equipment and staff, and have indicated by their performance that changing operating demands may be successfully met by a modification of basic locomotive design ratios to meet a wide range of conditions.

Among the pioneers in the introduction of new, streamlined steam locomotives and of correspondingly light cars to be operated therewith, are the Baltimore & Ohio; Chicago, Milwaukee, St. Paul & Pacific and the Canadian Pacific. These lines have built locomotives which have given outstanding results, the characteristics of these being shown in Table II.

Table II

| Railroad | B. & O. | C.M.St.P. & P. | C.P.R. |
|---|---|---|---|
| Wheel arrangement...... | 4-4-4 | 4-4-2 | 4-4-4 |
| Tractive effort—lb...... | 28,000 | 30,700 | 26,500 |
| Cylinders, dia. and stroke | 17½ by 28 in. | 19 by 28 in. | 17¼ by 28 in. |
| Boiler pressure—lb...... | 350 | 300 | 300 |
| Dia. driving wheels...... | 84 in. | 84 in. | 80 in. |
| Firebox, length and width | 159 by 78 in. | 132-1/16 by 75-3/16 in. | 114-1/16 by 70-3/16 in. |
| Grate area—sq. ft...... | 61.75 | 69.0 | 55.6 |
| Heating surface, firebox—sq. ft................ | *523 | 294 | 232 |
| Heating surface, tubes and flues—sq. ft......... | *1257 | 2951 | 2601 |
| Heating surface, superheater—sq. ft........ | 415 | 1029 | 1100 |
| Heating surface, combined sq. ft................ | 2195 | 4274 | 3933 |
| Total engine wheel base. | 35 ft. 5½ in. | 37 ft. 7 in. | 37 ft. 3 in. |
| Total wheel base........ | 71 ft. 4½ in. | 78 ft. 10½ in. | 70 ft. 8¼ in. |
| Weight on driving wheels lb................... | 99,800 | 140,000 | 120,000 |
| Weight engine, total—lb. | 217,800 | 280,000 | 263,000 |
| Weight engine and tender, total—lb ............ | 387,800 | 527,500 | 461,500 |
| Oil capacity—gal....... | .... | 4000 | .... |
| Coal capacity—tons.... | 14 | .... | 12 |
| Water capacity—gal..... | 8,000 | 13,000 | 7,000 |

*Water tube firebox.

At the present time the Canadian Pacific has under construction twenty more light high speed locomotives of a slightly modified design.

*Baltimore & Ohio:*—The trains used in connection with the locomotives described in the table consist of eight cars. Exclusive of the locomotive, the total length is 557 ft. 10 in.; total weight, when constructed of special steel, 780,000 lb.; when constructed of aluminum, 699,540 lb. The seating capacity of the train is 325. The consist of the train is as follows:—

1—Baggage and mail
2, 3 and 4—Reclining chair cars
5—Dining and lunch
6 and 7—Parlor cars
8—Parlor and observation

All cars are carried upon four-wheel single equalizer type trucks equipped with roller bearings. Cars are not articulated.

*Milwaukee:*—The trains which make up the Hiawatha trains of the C. M. St. P. & P. Ry. consist of nine lightweight cars. Exclusive of the locomotive, the total length is 737 ft. 0 in.; total weight 860,400 lb. and seating capacity 464. As arranged for service, the consist is as follows:—

1—Express, tap room
2, 3, 4 and 5—Coaches
6—Dining
7—Parlor
8—Parlor—Drawing room.
9—Parlor—Observation

Trucks are of the four wheel type equipped with roller bearings. Cars are not articulated.

*Canadian Pacific:*—Light weight trains constructed by the Canadian Pacific are of the semi-streamlined type, mounted on four-wheel trucks which have roller bearings. Cars are not articulated.

The original trains designed for day operation consisted of the following units:

1—Mail and baggage
2—Baggage—Buffet
3 and 4—Coaches

Exclusive of the locomotive, the total length of train is 319 ft. 3½ in.; total weight 441,700 lb.; cars have a seating capacity of 130.

Four trains are now in operation between Montreal and Quebec; Toronto and Windsor; and between Calgary and Edmonton. The spacious accommodation, ample lounge room space, modern construction, air conditioning and improved schedules of these trains have brought instant recognition of their success in meeting modern transportation requirements. Thirty additional cars are now under construction.

*Heavy Locomotives:*

To adequately handle heavy passenger trains of conventional equipment, heavier locomotives than those referred to are required. The latest Canadian locomotives designed for this purpose are the well-known 2800 class of the Canadian Pacific and the 6400 class of the Canadian National. The dimensions of these locomotives are given in Table III.

Table III

| Railroad | C.P.R. | C.N.R. |
|---|---|---|
| Wheel arrangement.................. | 4-6-4 | 4-8-4 |
| Tractive effort—lb.................. | 45,250 | 52,000 |
| Cylinders, dia. and stroke............ | 22 by 30 in. | 24 by 30 in. |
| Boiler pressure—lb.................. | 275 | 275 |
| Dia. driving wheels.................. | 75 in. | 77 in. |
| Firebox, length and width............ | 131-1/16 by 88-7/8 in. | 126¼ by 84-3/16 in. |
| Grate area—sq. ft.................. | 80.8 | 73.7 |
| Heating surface, firebox—sq. ft........ | 352 | 390 |
| Heating surface, tubes and flues—sq ft. | 3509 | 3471 |
| Superheating surface—sq. ft.......... | 1640 | 1530 |
| Combined heating surface—sq. ft...... | 5501 | 5391 |
| Total engine wheelbase............... | 39 ft. 6 in. | 44 ft. 1½ in. |
| Total wheelbase..................... | 80 ft. 6¼ in. | 82 ft. 7½ in. |
| Weight on driving wheels—lb.......... | 186,000 | 236,000 |
| Weight engine, total—lb.............. | 355,000 | 379,800 |
| Weight engine and tender, total—lb.... | 653,000 | 664,000 |
| Coal capacity—tons.................. | 21 | 20 |
| Water capacity—gal.................. | 12,000 | 11,700 |

*Under construction.

The Canadian Pacific locomotives are typical of the general trend to use 4-6-4 type locomotives for heavy passenger train service.

In England, where the weight of trains is normally much lighter than on American railways, streamlined steam locomotives are making enviable records for speed and reliability. The London & North Eastern Railway has announced that its new "Coronation" express will be scheduled to make the 392 mile run between London and Edinburgh in six hours.

The London, Midland & Scottish Railway recently covered 190 miles from London, St. Pancras Station, to Manchester in 202 minutes. On the return trip a speed of 91 miles per hour was attained, hauling a train of standard coaches.

The Great Western Railway and Southern Railway have kept abreast of the other lines in the operation of high speed schedules.

*Freight Locomotives:*

Freight train schedules have followed the trend of passenger train schedules. Increased speeds have changed the basis of operation from "gross tons handled" to "gross tons handled per train hour." The familiar freight locomotives, with small diameter driving wheels, moving "drag" tonnage slowly across the country, have been replaced by high wheeled locomotives either of the 4-8-4 type, or by articulated locomotives of new design. Representative of the latter development is the Union Pacific freight locomotive built in 1936. Its characteristics are as in Table IV.

Table IV

| | |
|---|---|
| Wheel arrangement | 4-6-6-4 |
| Tractive effort—lb | 97,400 |
| Cylinders | 4-22 by 32 in. |
| Boiler pressure—lb | 255 |
| Dia. of driving wheels | 69 in. |
| Firebox, length and width | 213-1/16 by 108¼ in. |
| Grate area—sq. ft | 108.2 |
| Heating surface, firebox—sq. ft | 625 |
| Heating surface, tubes and flues—sq. ft | 4756 |
| Superheating surface—sq. ft | 1650 |
| Combined heating surface—sq. ft | 7031 |
| Total engine wheelbase | 59 ft. 11 in. |
| Total wheelbase | 97 ft. 10½ in. |
| Weight on driving wheels—lb | 386,000 |
| Weight engine, total—lb | 566,000 |
| Weight engine and tender, total—lb | 876,000 |
| Coal capacity—tons | 22 |
| Water capacity—gal | 18,350 |

Internal Combustion Motive Power

Twenty-five years ago, public interest was engrossed in weighty arguments, backed by formidable arrays of statistics, concerning the respective merits of electric and steam locomotives.

Several extensive electrifications, mainly constructed to meet specific local operating conditions, were pointed out as examples of the ultimate adoption of electricity by the railroads of America.

Steam still holds the supreme position as the prime mover of the world's transport. The contentions of proponents for the general adoption of internal combustion locomotives for railway service remind one of these early prophecies.

Encouraged by a fairly general utilization of rail motor cars, mainly for branch lines, a light weight unit train, powered by Diesel oil engines, with electric transmission, has been heralded by some as the ultimate form of railway motive power. The blaze of publicity which has accompanied the introduction into service of each of these light weight unit trains is apt to cause one to overlook the fact that their number compared with the thousands of passenger trains in daily operation is as yet insignificant. Specially designed, light weight unit trains number but twenty-one in service on the following railways:—

| | |
|---|---|
| Chicago, Burlington & Quincy | 8 |
| Union Pacific | 6 |
| Atchison, Topeka & Santa Fe | 2 |
| Gulf Mobile & Northern | 2 |
| Boston & Maine | 1 |
| Illinois Central | 1 |
| New York New Haven & Hartford | 1 |
| Total | 21* |

*Two more are ready for service on the Baltimore and Ohio Railroad.

As a comparison, a study of the Diesel powered locomotives constructed, paralleled by a list of steam locomotives purchased may also be of interest:

Table V

| | Steam Locomotives | Diesel Locomotives** |
|---|---|---|
| 1925 | 1065 | 3 |
| 1926 | 1362 | 8 |
| 1927 | 792 | 4 |
| 1928 | 701 | 8 |
| 1929 | 1289 | 2 |
| 1930 | 535 | 51 |
| 1931 | 178 | 11 |
| 1932 | 12 | 5 |
| 1933 | 42 | 21 |
| 1934 | 182 | 16 |
| 1935 | 110 | 9 |
| 1936 | 534 | 42 |
| 1937 to May 1st | 331 | 35 |
| | 7133 | 215 |

**Mostly for switching service, including those for industrial work.

The total number of Diesel locomotives ordered comprises three per cent of the number of steam locomotives ordered during the same period.

In 1935 the author expressed his conviction that the newly designed, smaller, lighter, low powered Diesel unit train would not prove adequate to meet the requirements of flexibility in consist, and interchangeability in operation; neither would it be sufficient in spaciousness or comfort to meet the demands which were being developed. All recently constructed unit trains have been increased in length, increased in cross section and increased in power. The latest examples have two power units, and in some cases the auxiliary lighting and heating equipment has been given space in a portion of a third car. In other words, recent practice abandons the construction of unit trains and reverts to the practice of separate locomotive units, either single or double, with single control.

Modern Diesel Powered Passenger Trains

*Denver Zephyr (Chicago Burlington & Quincy R.R.)*

The latest example of the line of "Zephyrs" placed in service consists of a double power unit, hauling ten passenger units, operated between Chicago and Denver. Some of the units are united by articulation, in order to reduce the number of trucks required. The first section of the power units is 56 ft. 9 in. long and houses two 900 h.p., 12-cylinder V-type two cycle Diesel engines direct connected to direct current generators. The second section of the power units, 55 ft. 0 in. long, houses a 1,200 h.p., 16-cylinder V-type two cycle Diesel engine, also direct connected to a direct current generator. In this section, also, are a mechanical air compressor driven from the main engine shaft and two automatic oil fired boilers for generating steam for train heating.

The first revenue car contains auxiliary power equipment to supply current for the operation of lighting, refrigeration, and air conditioning equipment. The revenue units are arranged for the accommodation of the following services:

1—Auxiliary power, mail and baggage
2—Baggage, crew's quarters, cocktail lounge
3 and 4—Coach passengers
5—Dining
6, 7 and 8—Open section sleeping cars
9—Drawing room, bedroom, compartment sleeper
10—Parlor, observation lounge

Units 3, 4 and 5; 6 and 7; also 8 and 9 are articulated.

The car sheathing and structure is of stainless steel fabricated by a welding process. The structure is designed so that the roof and under structure act as compression and tension members of a beam, being connected by sides making up a Pratt truss, modified as necessitated to allow for doors and windows. The car is insulated in roof, sides, ends and floor.

Car trucks are of the four-wheeled, double equalizer, swing bolster type and have 33 in. diameter wheels, spaced 8 ft. 0 in. apart. Truck framing is composed of nickel steel double annealed and drawn castings. Journals are equipped with roller bearings.

The total length of the train, including locomotive, is 883 ft. 9 in.; total weight is 1,269,470 lb. (634.7 tons); weight per horse power of main engines being 423.1 lb.

The passenger accommodation of the train, exclusive of dressing room seats is as follows:—

| | |
|---|---|
| Coach passenger seats | 100 |
| Berths, upper and lower | 93 |
| Parlor car | 10 |
| Lounge and dining room | 104 |
| Total | 307 |

The present time schedule of these trains may be of interest and is shown in Table VI.

Table VI

| No. 1 Westbound (read down) | Miles | Stations | No. 10 Eastbound (read up) |
|---|---|---|---|
| CT—5.30 p.m. | 0 | Chicago | CT— 8.38 a.m. |
| CT—1.20 a.m. | 496 | Omaha | CT—12.49 a.m. |
| MT—8.30 a.m. | 1034 | Denver | MT— 4.00 p.m. |

CT—Central Time and MT—Mountain Time

| | Westbound | Eastbound |
|---|---|---|
| Total elapsed time | 15 hr. 58 min. | 15 hr. 36 min. |
| Total stopped time | 25 min. | 23 min. |
| Running time | 15 hr. 33 min. | 15 hr. 13 min. |
| Average speed—m.p.h. | 66.5 | 68.0 |

*City of Denver* (*Union Pacific R.R.*)

The most recent services inaugurated by Union Pacific light weight unit trains are those operating between Chicago and Denver. These are similar in make-up to the Denver Zephyr of the Burlington, each train consists of a double power unit and ten passenger units. The two sections of the power unit are articulated by means of a bridge spanning from the rear truck of the front section to the front truck of the rear section. Each section of the power unit houses a 1,200 h.p., 16-cylinder, V-type, two cycle Diesel engine, direct connected to a direct current generator. Auxiliary current for lighting, etc. is furnished by two separate Diesel engined generator sets.

The arrangement of the revenue cars is as follows:—

1—Mail
2—Baggage
3—Baggage and tap room
4 and 5—Coaches
6—Dining
7, 8 and 9—Sleeping cars
10—Observation car

Units 4 and 5; 7 and 8; and 9 and 10 are articulated.

The locomotive units are sheathed with Cor-Ten steel plates. The revenue units have aluminum plate sheathing, attached to a strong framing, the parts of which are made of strong aluminum alloys; extruded aluminum sections are used for side sills and upper longitudinal members.

Trucks are of the four wheel type. The locomotive trucks are 8 ft. 4 in. wheel base and have 36 in. diameter wheels; car trucks are 8 ft. 0 in. wheelbase and have 34 in. diameter wheels.

The total length of the train is 864 ft. 0 in.; total weight is 1,250, 450 lb. (625.2 tons); weight per horse power of main engines is 521.0 lb.

The passenger accommodation furnishes seating capacity for 272 persons. The present schedule of the "City of Denver" trains appears in Table VII.

Table VII

| No. 111 Westbound (read down) | Miles | Station | No. 112 Eastbound (read up) |
|---|---|---|---|
| CT —6.20 p.m. | 0 | Chicago | CT—9.23 a.m. |
| CT —2.10 a.m. | 488 | Omaha | CT—1.35 a.m. |
| MT—9.20 p.m. | 1048 | Denver | MT—4.45 p.m. |

CT—Central Time and MT—Mountain Time

| | Westbound | Eastbound |
|---|---|---|
| Total elapsed time | 15 hr. 52 min. | 15 hr. 36 min. |
| Total stopped time | 17 min. | 12 min. |
| Actual running time | 15 hr. 35 min. | 15 hr. 24 min. |
| Average speed-m.p.h. | 67.2 | 68.0 |

*Super Chief* (*Atchison, Topeka and Santa Fe R.R.*)

The latest Diesel powered unit train to be placed in service is the "Super Chief" operating between Chicago and Los Angeles on a 39-3/4 hour schedule, over the lines of the Atchison, Topeka and Santa Fe. This train, similar generally to the trains of the Burlington and Union Pacific, consists of a two section power unit of 3,600 h.p. with separate coaches, without articulation.

Each of the two sections of the locomotive contains two 900 h.p, 12 cylinder, V-type, two cycle engines direct connected to a d.c. generator. The consist of the revenue units is as follows:—

1—Mail, storage, post office
2—Mail, storage, baggage
3 and 4—Sections, compartments, drawing rooms
5—Bar, lounge, barbershop, crew
6—Dining
7 and 8—Bedrooms, compartments, drawing rooms
9—Bedroom, compartments, drawing room observation

The total length of the train, including locomotive is 856 ft. 11-3/4 in.; total weight is 1,419,000 lb., (704.5 tons); weight per horse power of main engines being 394.1 lb.

The passenger accommodations comprise:—

| | |
|---|---|
| Sleeping car berths | 104 |
| Dining car seats | 36 |
| Observation lounge, etc | 42 |
| | 182 |

The construction of the cars, arrangement of space and details of design are of the latest space and weight saving design.

This train embodies complete separation of motive power from the train units and also has been built without truck articulation, in order to obtain the same flexibility of consist which is found in steam operated practice.

### Modern Diesel Switching Locomotives

The typical modern Diesel electric switching locomotive consists of a 600 h.p. Diesel electric engine, usually having 6 vertical cylinders, direct connected to a d.c. generator.

The frame, of welded steel or cast steel construction, is mounted on two 4-wheel trucks. The engine and generator are enclosed within a steel weatherproof housing; the cab being located at one end of the locomotive.

A recent representative switching locomotive has the specifications in Table VIII.

Table VIII

| | |
|---|---|
| Weight on drivers, loaded | 212,000 lb. |
| Length | 39 ft. 6 in. |
| Height to top of cab | 14 ft. 3 in. |
| Rigid wheel base | 8 ft. 0 in. |
| Total wheel base | 26 ft. 0 in. |
| Tractive force (30 per cent adhesion) | 63,600 lb. |
| Tractive force (at continuous rating of motors) | 29,900 lb. |
| Speed (at continuous rating of motors) | 5.7 m.p.h. |
| Speed, maximum | 45.0 m.p.h. |

The development of the oil electric switching locomotive for American railway and industrial service commenced in 1923, the first successful locomotive weighing 55 tons, with a 6 cylinder, 300 h.p. Diesel engine direct connected to a d.c. generator.

While oil electric switching engines have, in some cases, been favoured over a steam locomotive, on account of ability to develop high tractive effort at low speeds, the oil electric lacks the flexibility in operation of the steam locomotive and must be carefully selected as to type and suitably assigned for service, if the benefits of its performance are to balance the high initial cost of the unit, and overcome other objectionable features. There has been a tendency, when making comparisons, to overlook the fact that the steam locomotives which have been replaced by oil electric switching locomotives have usually been obsolete engines of an uneconomic type.

### Modern Trends in Railway Motive Power

The trend of modern motive power is dependent largely upon local conditions and economic influence. On account of the small population of the Dominion, as compared with that of the United States; long distances through sparsely settled territory; need of furnishing adequate service to small communities along the line, and the severe winter weather conditions encountered, it is doubtful whether any other form of motive power can as successfully meet the range of limitations involved in Canadian railway service as can the steam locomotive.

A comparative study of the characteristics of an oil electric light weight unit train as compared with one operated by steam locomotives, must be based upon the following factors:—

(1)—Economical first cost
(2)—Economical maintenance
(3)—Adequate power
(4)—Safety
(5)—Comfort
(6)—Reliability, flexibility, speed, etc.

*Economical Cost and Maintenance:*

Admitting that the Diesel engine operates at a low fuel cost, and has high thermal efficiency, there are still many problems to be solved before its suitability for Canadian main line train service can be established.

The first cost of Diesel electric equipped locomotives must be materially reduced before they can be accepted. A comparison of costs follows in Table IX.

Table IX

| | Steam Train (including locomotive) | Gas Electric Rail Car | Light Weight Diesel Electric Train |
|---|---|---|---|
| Cost per pound | $0.30 | $0.48 | $0.95 |

These are actual Canadian prices except for the last item, which is based on conservative prices in the United States, which are approximately 45 per cent below Canadian prices for duplicate equipment. In this connection the latest trend is to the use of double unit Diesel locomotives for handling light weight trains. While this permits the installation of adequate power capacity, it doubles the initial cost, doubles the non-revenue weight, duplicates the mechanical and electric equipment and greatly increases maintenance costs. When in addition to devoting the entire space of the two first units of these trains to motive power equipment, the third unit is also partly taken up by the generating equipment for lighting, air conditioning and refrigerating, the revenue-producing space becomes unduly restricted. One recent example has less than 80 per cent of the train available for traffic accommodation.

When analysis is being made of fuel costs for Diesel operated light weight trains, it must be borne in mind that usual comparisons cited are not with those of a similar light weight steam train but with those of a heavy locomotive handling a train of heavier conventionally designed cars on an entirely different standard of service.

One of the chief points brought out to favour internal combustion power is the elimination of the locomotive boiler and its very high cost of repairs and maintenance, which may be saved by using the newer form of power. As actually these maintenance costs constitute only 19 per cent of the total cost of steam locomotive maintenance, they are not out of proportion to the total nor do they present a forceful reason for the abandonment of steam. Again, should figures purporting to show a striking reduction of fuel costs in favour of Diesel engines be placed upon a cost per ton-mile basis, the result is not so damning to the steam powered locomotive. The fuel cost of Diesel electric units is small because the tonnage moved is small. Comparative costs follow in Table X.

Table X

| | Diesel Electric Light Weight Train | Gas Elec. Car | Steam Passenger Train | Steam Freight Train |
|---|---|---|---|---|
| Cost of fuel per ton for one mile | $0.00114 | $0.001 | $0.00086 | $0.00004 |

If the cost of steam freight service represents unity, the comparison is as follows:—

28 25 21 1

*Note.*—Figures above are based on a gasoline cost of $0.15 per U.S. gallon; locomotive performance on cost of coal in U.S., Diesel electric costs on advertised performance of Union Pacific train; gas electric car on actual Canadian Pacific costs.

Fuel costs at best are indefinite. They are influenced by condition of engine, particularly worn cylinders, valves, pistons and rings, causing loss of compression; inaccurate fuel injection, inadequate scavenging, and weather conditions. Low temperature and heavy snow will increase fuel consumption. A general increase in demand for suitable fuel oil and a depletion in the available oil supply cannot fail to be reflected in increased fuel costs.

Maintenance costs for existing Diesel electric equipment are also very indefinite. The equipment has not yet been in service long enough to establish any standard of maintenance expense. Even successive individual units placed in service by the same railway have been radically changed in mechanical and electrical equipment, size of units, and length and weight of train. That the service of existing latest equipment can be perpetuated by means of modernization and rebuilding, as is the practice with

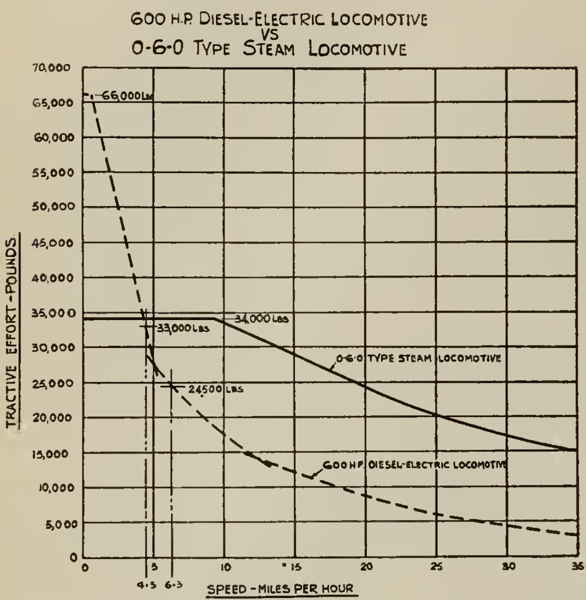



Fig. 4—Speed-Tractive Effort Curves, Switching Locomotives.

steam locomotives, has not yet been established. To maintain internal combustion engines and electrical equipment necessitates expensive installations of shop machinery, specially trained maintenance staff and probably the purchase of repair parts at high cost from the manufacturers. Obsolescence of the oil electric equipment through the development of weight reducing and fuel conserving designs, will make it probable that the cost of maintaining these units will always compare unfavourably with similar costs for steam locomotives.

*Adequate Power:*

The Diesel engine has no starting torque at zero speed, therefore its installation must include some means of converting a practical and economical engine speed to a low speed, high torque equivalent, at the driving wheel. Electric transmission involves a dual conversion, between engine and rail. It is, so far, the most successful transmission for locomotive use.

To equal the horse power output of a steam locomotive at high speeds, a very large, heavy Diesel installation is required at a cost approximately three times that of equivalent horse power in steam power.

Most of the Diesel electric locomotives are used in switching service. Figure 4 illustrates the comparative speed-tractive effort curve of a 600 h.p. Diesel electric locomotive compared with that of the steam locomotive which it replaced. Note the rapid decline in tractive effort of the oil electric locomotive at speeds between 5 and 10 m.p.h. This locomotive has two 300 h.p. engines, thus duplicating the number of parts to be maintained.

Dimensions of the two locomotives follow in Table XI.

Table XI

| | Steam | Diesel Electric |
|---|---|---|
| Weight on driving wheels—lb. | 169,000 | 215,650 |
| Dia. of driving wheels | 51 in. | 40 in. |
| Cylinders, dia. and stroke | 21 by 26 in. | 2 sets-6 cyl. 10 by 12 in. |
| Boiler pressure—lb. | 180 | .... |
| Tractive effort, max.—lb. | 34,000 | 66,000 |
| " " (1-hr. rating 4-5 m.p.h.) | .... | 33,000 |
| " " (continuous rating 6.3 m.p.h.) | .... | 24,500 |

Since the steam locomotive maintains a tractive effort of 34,000 lb. to approximately 9 miles per hour, it is 28 per cent more powerful than the Diesel electric within the range of switching speeds.

A striking example of the increased power which must be installed to overcome the tractive limitations of oil electric equipment is indicated by the use of 3,600 h.p. engines in the Super Chief of the A.T. and S.F. The trailing load behind the locomotive is 425.5 tons, being equivalent to one horsepower for each 236.4 lb. of revenue rolling stock. In steam practice one horsepower for each 500 lb. of train is ample for reliability of service.

*Safety:*

Reduction in weight lessens the impact when a light train suffers collision with another train or object but the damage sustained would probably be increased. Reduction in weight also increases the tendency for the lighter train to be derailed should an obstacle be encountered. Consideration for safety indicates that such reduction should be confined to a point where the hazards of operation should not be increased.

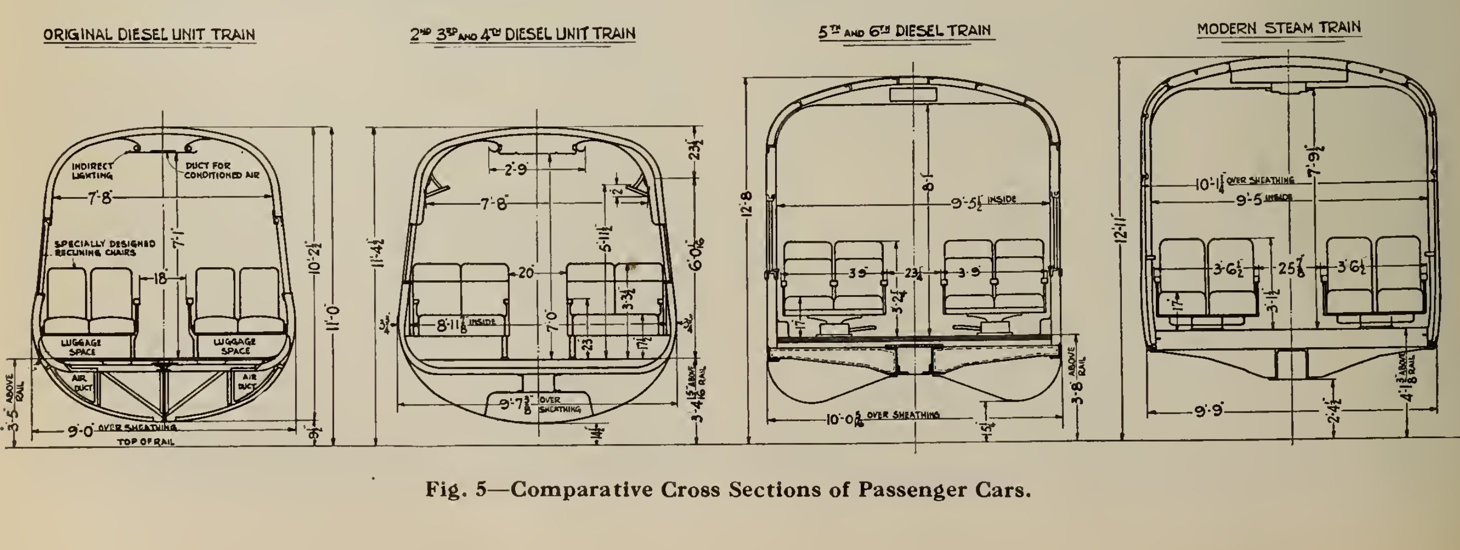



Fig. 5—Comparative Cross Sections of Passenger Cars.

*Comfort:*

Comfort in a railway train depends upon adequate space and accommodation coupled with good riding qualities. The diagrams of passenger equipment outlined in Fig. 5 indicate the modification of the cross section of cars of the first highly advertised light weight unit train, as later units were built, compared with the cross section of the latest Canadian Pacific coach at the extreme right. The original unit cars are low, narrow and restricted in seat and aisle space. The latest unit trains approach the dimensions and adequate air space per passenger of standard steam-train cars.

To overcome the disturbing forces of movement over inequalities of track surface, rail joints, crossovers, switches, etc. weight cannot be decreased to a point where resistance to such influences is inadequate. As speeds are increased this becomes more important.

In Canada, riding comfort is also materially affected by accumulations of snow and ice on the trucks and undergear of cars. To provide comfort in severe weather, adequate insulation and heating equipment is essential. In Canada auxiliary heating equipment, for use when steam is not available, is necessary. This equipment increases the weight of the cars and must be compensated for by additional motive power capacity.

*Reliability:*

There are few mechanical devices which have the proved reliability of a steam locomotive. Only the breakage of a major part can cause a complete failure. This reliability is not inherent in an oil electrically equipped unit having a multiplicity of moving and wearing parts, coupled with a probability of trouble with the electrical apparatus. In this connection, the most serious service failures of gas electric rail cars on the Canadian Pacific have been those of the electrical control and motive equipment.

For reliability an ample power reserve must be installed. To do so by duplicating Diesel engines increases cost, weight, maintenance and liability to failure.

*Flexibility:*

To provide for varying traffic demands, the standard practice on railways has been to increase or decrease the number of cars in the train. Unit trains, designed to be so operated, and powered with a capacity to suit, cannot adequately meet rapidly changing requirements for equipment. This is more definitely the case when cars of the unit have been articulated. In the latest trains this has led to the abandonment of articulation and to the separation of the power units from the revenue units. They do not have, however, the capacity of the steam locomotive to cope with increased tonnage due to increased number of cars in the train.

To install high speed trains, either oil electric or steam powered, involves increased maintenance of right of way, curves must be modified, grades reduced, bridges and culverts checked, protective devices installed or relocated and train operating rules revised. All this means increased maintenance costs, if high speeds may be undertaken with complete confidence. Whether the gain in time warrants such expenditures is problematical.

Streamlining has a strong popular appeal and has been prolifically advertised. At ordinary speeds its value is minimized and in no case does it effectively counteract the effect of heavy side or quartering winds against a moving train.

It is to be regretted from many angles that high pressure publicity has given the public the opinion that in Diesel powered light weight unit trains the acme of perfection in passenger travel has been reached and that such trains are an unqualified success. In reality, the modern steam locomotive and train offer more in comfort, safety and consistent speed than their newer rivals and accomplish this at less first cost, less mechanical complication and with more reliability.

While the thermal efficiency of the locomotive may be surpassed by that of some high pressure stationary installations, it is essentially efficient when considered as a concentrated, mobile power plant. It is capable of developing as much as 4,000 h.p.; receiving while in operation only the partial attention of a two man crew continually diverted by observing track, signals, etc.

It carries with it compactly all the necessities for rapid steam generation. A stationary plant of similar capacity would require nearly half an acre of ground space and would have a staff of at least five times as many men, devoting their complete attention to the functioning of the equipment.

### General Comments

The steam locomotive is over 100 years old. Adhering basically to its original design, it has met every evolution of transportation and is likely to continue as the world's supreme motive power. By gradual change in detail it has produced a constant improvement in fuel performance, horse power capacity and dependability. Thermal efficiencies have been improved by increasing boiler pressures. Boiler proportions have been altered to permit better heat transfer.

Riding qualities have been improved, giving greater stability at high speeds. Without increasing height and width clearance dimensions, locomotive power has been increased for the same weight on driving wheels as much as 50 per cent.

Long runs have demonstrated the reliability of steam locomotives, operated with little maintenance at intermediate points. Canadian Pacific passenger locomotives operate from Winnipeg to Calgary (831.7 miles) and from Calgary to Revelstoke (262.3 miles) without change. The latter run covers mountainous territory with severe grades.

It is certain that further research and experimentation will bring forth additional improvements in the design and performance of steam locomotives. There is as yet no definite general inclination in the direction of abandoning steam transport for other power instruments and it is doubtful whether as yet this is economically possible.

It is the opinion of the author that the steam locomotive will continue to predominate for some years to come; will haul our freight, transport our passengers and unite our communities by efficient, adequate service.

# THE ENGINEERING JOURNAL

## THE JOURNAL OF THE ENGINEERING INSTITUTE OF CANADA

"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."



VOLUME XX SEPTEMBER, 1937 No. 9

## Safety Features in Automobile Design

It is a commonplace to say that motor car design should be based on research. But what kind of research? As regards strength of construction, or the mechanical and electrical details of the power equipment, standard principles apply, and experimental data are available. There are, however, many features of design involving safety considerations which as yet cannot be studied by the engineer's regular methods of numerical analysis, since their effect depends on human nature as well as on the properties of materials.

The average automobile owner, in reply to the circulars sent out by the Customers' Research Departments of the great motor manufacturers, may be able to say whether he prefers maroon as a colour, or whether he would like his car to have hydraulic brakes, but his answers do not help to find out what features in existing automobile design should be changed to promote safety on the road, and if so, what the changes should be. For this purpose indeed the only source of useful information would seem to be the statistics and reports of such accidents as appear to be due to some characteristic of the car itself. No doubt the automobile of today has faults in design, but accident statistics as now collected throw no light on their relative importance as regards the occurrence or the severity of accidents.

Apparently only a small proportion, some six per cent, of automobile accidents are reported as being due to some fault in the vehicle itself. Further, in the majority of these comparatively few cases, lack of proper maintenance is the contributing cause, not the design of the car.

These facts indicate that so far as performance is concerned, present day automobile designers have given us a safe and reliable product, but that many of the automobile's limitations as regards safety arise from other factors, some of which are psychological, or physiological, and have to do with the effect of the car itself on such matters as the driver's vision, his liability to fatigue and his skill in controlling the car.

Automobile engineers are well aware of this situation and are devoting attention to it. The problems involved in the relation between automobile design and safety were featured at a recent meeting of the Society of Automotive Engineers. In a paper* by an officer of General Motors Corporation, the author presented an interesting summary of the ideas of the members of the Society on present day motor vehicle design viewed from the standpoint of safety on the highway. His analysis was based on opinions and data contributed by the various engineering organizations in the industry.

This discussion dealt only with passenger cars and covered in a general way such major topics as driver's vision, car control, and the "roadability" of the car.

In connection with the thorny question of headlights, it was noted that the problems of glare and insufficient road illumination have been complicated by attempts to comply with headlight specifications developed years ago by highway authorities when conditions were quite different, speeds were low, and only single beam lamps with narrow concentrated beams were available. The newer multiple beam systems, with better road-edge illumination, have done much to relieve the situation, by providing a driving beam for the open road and a diverted beam for meeting other cars, thus recognizing the fact that any adequate distant illumination of the road by the car headlights must glare the opposing driver.

Regarding schemes for using polarized light, or colour filters, the consensus of opinion seemed to be that these are impractical, not because they will not work, but because they require the uniform equipment of every car with two complete systems, one for projection and one for vision, plus the education of all drivers in their use. Some relief would be found in four-lane roads, in which the streams of traffic are more widely separated.

As for brakes, opinion varied as to the desirable distribution of braking power between front and rear wheels, especially having regard to the effect in cornering, since brakes must often be used on curves. The high speed and power of modern cars increase the difficulty of designing braking systems which will not become more sensitive as they wear, or will not "fade" during a single application.

On the whole it would seem that the brake designer has succeeded fairly well in meeting the requirements of increased car speed, even with the smaller space now available for his equipment.

In discussing the limitation of the driver's vision due to the construction of the car, it is considered that front road vision is reasonably good in the modern cars. Presumably however, the level of the passenger's eyes, or the roof over his head, will not be lowered further in the quest for reduced wind resistance and a lower centre of gravity.

Good wiper and defroster equipment is now available, though nobody has yet found out how to keep a windshield clear on a dirty road in heavy traffic when there is no rain to remove the mud splashes. Rear vision has been reduced rather than improved in recent passenger car models, but it is believed that such restrictions as have been made in driver vision have really been the result of improvements which have themselves contributed to safety.

The subject which seems to call most urgently for careful investigation is that of crash dangers. For this the experience of surgeons and hospitals is becoming increasingly available. The scope of such an enquiry would have to be very wide.

*Automobile Design and Safety, John H. Hunt, S.A.E. Journal August 1937.

The driver often escapes injury in minor crashes, but in more severe shocks is liable to damage by the cowl board or the steering wheel. An enquiry is suggested as regards safety glass, since the question has been raised whether in severe crashes, the fine splinters of safety glass may not cause more serious injury than the larger pieces of ordinary plate glass. Adequate information on this important point is needed. Similarly data are needed regarding injuries caused by bumpers, door handles and radiator ornaments. It must be remembered that these are matters affecting the equipment of millions of cars.

All motorists realize the great reduction in driving fatigue which has resulted from the quiet running, easy steering and adjustable seats of the modern car as compared with the type usual only five years ago. Improvements in car design however do not help the really tired driver to keep up the continuous attention to driving which is the first requisite for safety. The only proper remedy is for the tired driver to cease driving.

It appears from actual tests that the alleged effect of ventilating systems in drawing carbon monoxide into the car body is imaginary, unless there are openings in the car floor and a leaky exhaust line. Carbon monoxide in a car comes almost invariably from the exhaust of the car ahead.

The term "roadability" refers to those car characteristics which affect the handling of the car on the road. The response of the car to the driver's will, as regards speed and direction, should be such as to require no fatiguing mental or physical effort, and should call for the exercise of no unusual degree of skill on the driver's part. In the modern car the engine responds so readily and smoothly to sudden demands for power that the driver hardly thinks of it. There are occasions, however, as in overtaking another vehicle, when hesitation in the power supply might have serious results. This is why the introduction of speed-limiting governors on passenger cars is open to serious objection.

As regards steering, the discussion stresses the difficulty of adjusting the weights and proportional braking on front and rear wheels, and the amount of load transferred from the inner to the outer tires on a curve, so as to avoid "oversteer," by which is meant an unstable condition while cornering, in which the rear of the car tends to swing out farther than the front end. Actually a car with moderate "understeer" is desirable as giving good handling in the constantly changing conditions of road surface, road camber, and wind, met with in ordinary straight ahead driving.

On the whole the views expressed in Mr. Hunt's paper seem to present rather the disadvantages than the advantages of the various proposals considered. This is perhaps due to the method the engineer must follow in making his decisions. He must think of all possible objections to a piece of equipment, and then seek to avoid these objections when making his design.

A number of faults were pointed out during the discussion but the conclusions were in many cases not so definite as might be wished. Unfortunately no data are available to show whether cars which have more of these faults are involved in more accidents than cars having fewer of them, and, if so, whether this greater number of accidents is the result of the greater number of faults.

An investigation on this point would obviously present great difficulty. Actually it is only one of several subjects suggested as needing thorough enquiry, each involving a number of puzzling factors. It would seem that to make definite progress in these matters, the automobile designer will have to collaborate with safety engineers, public officials responsible for safety regulations, highway engineers and, in regard to certain questions, with surgical authorities and perhaps even psychologists.

## Guglielmo Marconi

By the death of the Marchese Marconi, the electrical engineering world has been deprived of one of its greatest pioneers. He died at his home in Rome on July 20th, at the age of sixty-three. He was born at Bologna on April 25th, 1874, and was of mixed parentage, his father being an Italian country gentleman who married an Irish lady.

Guglielmo Marconi, as a boy, took a keen interest in physical and electrical science. In 1895 he conceived the idea that a system of telegraphy through space could be provided by means of electric waves, the existence of which had been foreseen mathematically by Clerk Maxwell in 1864, and later investigated experimentally by Hertz, Oliver Lodge, Righi and others. Marconi, however, was the first of these pioneers to devise the practical means whereby they could be made to provide a new method of telegraphic communication.

In the early summer of 1895 Marconi conducted a number of experiments at his father's country house at Pontecchio, near Bologna. These experiments soon began to give remarkable results, communication being established in that year over distances in excess of one mile. In these early days Marconi also discovered that the distance of communication increased very rapidly if the height above ground of the elevated aerials was increased.

Coming to England in 1896, Marconi continued his experiments in London, and in that year demonstrated his invention before officials of the Post Office and foreign Government Departments. In 1897, at the invitation of the Italian Government, Marconi went to Spezia, where a land station was erected and communication with Italian warships was established up to a distance of 12 miles.

Wireless telegraphy was first used for commercial purposes in 1898, when the Kingstown Regatta races were reported by Marconi by means of wireless apparatus installed on a tug which followed the yachts on the Irish Sea. The utility of wireless in saving life at sea was demonstrated for the first time when, on March 3rd, 1899, a steamer collided with the East Goodwin lightship. Wireless apparatus had been installed on the lightship and on the shore at the South Foreland lighthouse. The accident was at once reported by wireless to the lighthouse and lifeboats were promptly despatched to the assistance of the light vessel. In March, 1898, Marconi established communication by wireless across the English Channel, between England and France. The wireless conquest of the Atlantic Ocean may be regarded as the culminating point of his pioneer work. On December 12th, 1901, he, on his first attempt, succeeded in transmitting and receiving signals from the long-distance wireless telegraph station at Poldhu, in Cornwall, to St. John's, Newfoundland. This achievement completely confirmed his opinion that electric waves would not be stopped by the curvature of the earth.

In 1905 he took out his patents for the horizontal directional aerial, which marked an advance in the design of long-distance stations. In 1916, during the war, experiments were commenced by Marconi in Italy with very short waves, with the object of devising a directive or beam system of wireless telegraphy. His anticipations were justified by the results obtained since that time by British and foreign experimenters. In 1924 he was the first to discover that short waves of the order of 30 m. in length could be transmitted and received over great distances during daylight.

The value of Marconi's work has been recognized by Governments, universities, and learned societies all over the world. In 1914 he was made a member of the Italian Senate, and in June, 1929, was created a hereditary marquis by the King of Italy.—*The Engineer* (abridged).

## OBITUARIES

### Colonel John Houliston, A.M.E.I.C.

We regret to announce the death in Ottawa on August 8, 1937 of Col. John Houliston, D.S.O., of the Royal Canadian Engineers (retired) and at one time District Officer Commanding, Military District No. 7, at Saint John, N.B.

Col. Houliston was born in 1868 at Three Rivers, Quebec, and graduated from the Royal Military College, Kingston, Ont., in 1890. Between graduation and 1904, when he received the appointment in the Royal Canadian Engineers, he was engaged in various engineering works and services in the vicinity of Three Rivers, principally in connection with the proposed improvements of the Three Rivers' Harbour Commission. During his career with the Royal Canadian Engineers he held the appointments of Director of Works and Buildings and Director of Engineer Services. Col. Houliston saw considerable service overseas during the war. In 1922 he was appointed as D.O.C. for Military District No. 7, retiring on pension two years later.

Colonel Houliston joined the Canadian Society of Civil Engineers as a Student in 1898, and transferred to the grade of Associate Member in 1899.

### Louis Philippe Roy, S.E.I.C.

The death of Mr. Louis Philippe Roy (aged 26) occurred July 16, 1937, as the result of a drowning accident. Mr. Roy joined The Institute as a Student in 1936 and graduated from the Ecole Polytechnique, Montreal, in 1937. At the time of his death at Chibougamau he was employed as a civil engineer with the Quebec Government.

### L. Ernest F. Fusey, A.M.E.I.C.

Members of The Institute will learn with regret of the death of Ernest Fusey, which occurred in Montreal on July 31, 1937. Mr. Fusey, prior to his retirement some five years ago was superintending engineer of the Sewerage Department, City of Montreal. He was born at St. Barthelemy, Que., in 1864, and was educated at the Ecole Polytechnique, Montreal, graduating in 1890. During the early part of his career, Mr. Fusey was employed as assistant engineer by the Department of Roads and Canals in Quebec and the Maritime Provinces and in 1906 became a member of the engineering staff of the City of Montreal. He joined the Canadian Society of Civil Engineers as an Associate Member in 1899 and became a Life Member in May 1931.

## PERSONALS

Captain N. J. W. Smith, R.C.E., S.E.I.C., has recently been transferred to Fort Canning, Singapore, Malaya. Capt. Smith is a graduate of Royal Military College at Kingston, Ontario and McGill University in 1932 and lately has been with the 1st Division Bridging Camp, Royal Engineers, Weymouth, England.

Eric C. Molke, A.M.E.I.C., formerly with H. G. Acres & Company, Niagara Falls, Ont., has accepted a position as structural engineer with Roberts and Schaefer Company, Chicago, Ill. Mr. Molke is a graduate of the Technische Hochschule, Vienna. Coming to Canada in 1922 he secured employment with the Trussed Concrete Steel Company of Canada, Walkerville, Ont. and from 1928 to 1932 was designing engineer in the Slave Falls division of the Hydro Electric System of the city of Winnipeg.

T. H. Doherty, A.M.E.I.C., has accepted an appointment on the engineering staff of the Coca-Cola Company, Toronto, Ont. Mr. Doherty graduated from McGill University in mechanical engineering in 1929 after which he joined the Riley Engineering and Supply Company, Toronto. From 1930 to 1932 he was with the Lima Locomotive Works, Lima, Ohio, then accepted a position as junior research engineer with the Fire Hazard Testing Laboratories of the National Research Council, Ottawa.

Cyril J. Carey, A.M.E.I.C., is now located in Halifax, N.S., where he is carrying on a practice as consulting engineer. Mr. Carey has been in private practice in St. John's, Newfoundland since 1931, engaged in general structural and survey work. He received his early education in Halifax, N.S., St. John's, Newfoundland and in England. From 1925-31 he was with the Engineering and Highroads Commission in Newfoundland, latterly as chief assistant to the chief engineer. His work included inspection, structural design and survey in connection with highways, harbours, water and sewerage supply systems and general building construction.

A. C. Herbert, S.E.I.C., has recently entered the engineering department of the Canadian National Telegraphs, Toronto, Ontario. Mr. Herbert graduated from the University of Alberta in electrical engineering in 1935 and entering the Royal Canadian Corps of Signals was located at Camp Borden, Ontario.

F. R. Killam, S.E.I.C., recently received an appointment with the Fraser Companies Limited at Edmundston, N.B. Mr. Killam graduated from McGill University in 1927, when he received the degree of B.Eng.

Howard Kennedy, M.C., M.E.I.C., formerly manager, Woodlands Department, E. B. Eddy Company Limited, has recently been appointed manager of the Quebec Forest Industries Association Limited. Mr. Kennedy graduated from McGill University in 1914 and joined The Institute in 1921 as an Associate Member. He served overseas for four years as Lieutenant and Captain in the 7th Field Company Canadian Engineers and on his return to Canada entered Lockwood Greene & Company. Later he became resident engineer with the Dominion Tire Company, Kitchener, Ont. and the Maple Leaf Rubber Factory, Port Dalhousie, Ontario.

D. Campbell Mackenzie, M.E.I.C., has relinquished his position as general manager of the Consolidated Alluvials of B.C. Limited, to resume his practice as consulting mining engineer; he has been retained, however, as consulting engineer for the above company. Mr. Mackenzie received his early technical education in Scotland and in 1907 was appointed Inspector of Mines and Machinery for the Department of Mines, New South Wales. He served overseas on active service as lieutenant with the 2nd Australian Tunnelling Company from 1915 to 1919, after which he resumed his duties in the Department of Mines. In 1922 he was appointed general manager for the Corrabin Coal Fields, New South Wales and later became manager of the Catamaran Collieries Limited, Tasmania. In 1926 he moved to Vancouver, B.C., where he set up practice as consulting mining engineer.

Victor Shanks, S.E.I.C., a graduate from the University of Toronto in 1935 is now located with the Sangamo Company Limited in Toronto. Mr. Shanks was previously with the Gutta Percha and Rubber Limited, Toronto.

# JOINT MEETING IN BOSTON, MASSACHUSETTS

## THE ENGINEERING INSTITUTE OF CANADA

and

## THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Wednesday, Thursday and Friday, October 6th, 7th and 8th, 1937

HEADQUARTERS AT THE HOTEL STATLER

# Programme of Meetings, Entertainment and Trips

**WEDNESDAY—OCTOBER 6th—**

*Morning:*

**9.00** REGISTRATION—(Mezzanine Floor).

GENERAL MEETING—(Imperial Ballroom).

**10.00** **Joint Session** called to order by FRANK A. BARBOUR, M.E.I.C., M.Am.Soc.C.E., Chairman, Local Committee on Arrangements; Consulting Engineer, Boston, Mass.

**10.05** **Addresses of Welcome**

ALBERT HAERTLEIN, M.Am.Soc.C.E., President, Northeastern Section; Associate Professor of Civil Engineering, Harvard University, Cambridge, Mass.

HIS EXCELLENCY, THE GOVERNOR OF THE COMMONWEALTH OF MASSACHUSETTS.

HIS HONOUR, THE MAYOR OF THE CITY OF BOSTON.

**10.30** **Responses**

LOUIS C. HILL, M.Am.Soc.C.E., President, American Society of Civil Engineers.

GEORGE J. DESBARATS, Hon.M.E.I.C., President, The Engineering Institute of Canada.

**10.45** **Brief Addresses** by JAMES BRYANT CONANT, President of Harvard University.

KARL TAYLOR COMPTON, President of the Massachusetts Institute of Technology.

**11.00** **Address:—Culture and Technical Background of the "New Architecture"** by

WALTER GROPIUS, Professor of Architecture, Harvard University.

**12.00 to 2.00** STUDENTS' LUNCHEON—(Salle Moderne)

COLONEL CHARLES R. GOW, M.Am.Soc.C.E., presiding.

Speaker: COLONEL WILLARD T. CHEVALIER, Past Director, Am.Soc.C.E., Vice-President, McGraw-Hill Publishing Co., Inc., New York.

All Members of The Institute and the Society will be welcome. Tickets: $1.50.

*Afternoon:*

GENERAL MEETING—(Imperial Ballroom)

JOINT MEETING CONDUCTED BY THE ENGINEERING INSTITUTE OF CANADA.

*Chairman* — FRED NEWELL, Member of Council, E.I.C., Assistant Chief Engineer, Dominion Bridge Co., Ltd., Montreal.

**2.00** **Substructure of the New Highway Bridge over the Fraser River at New Westminster, British Columbia** by

MAJOR WILLIAM G. SWAN, M.E.I.C., Consulting Engineer, Vancouver, British Columbia.

Discussion opened by R. E. C. CHADWICK, M.E.I.C., President, The Foundation Co., of Canada Ltd. and LEWIS E. MOORE, M.Am.Soc.C.E., Consulting Engineer, Boston, Mass.

**3.00** **Recent Developments at the Port of Halifax, Nova Scotia** by

EDWARD H. JAMES, M.E.I.C., Consulting Engineer, Montreal, Quebec.

Discussion opened by JOHN B. STIRLING, M.E.I.C., Engineer, E. G. M. Cape & Co., Montreal,

(*Harvard Institute of Geographic Exploration*)

The State House and Boston Common

JOINT MEETING — (*Continued*)

RICHARD K. HALE, Assoc.M.Am.Soc.C.E., Associate Commissioner, Mass. Department of Public Works, Boston, Mass., and J. STUART CRANDALL, M.Am.Soc.C.E., President and Chief Engineer, Crandall Dry Dock Engineers, Cambridge, Mass.

4.00 **The Conception and Design of the Outardes Hydro-Electric Project** by
HENRY G. ACRES, M.E.I.C., Consulting Engineer, Niagara Falls, Ontario.
Discussion opened by
H. K. BARROWS, M.Am.Soc.C.E., Professor of Hydraulic Engineering, Mass. Institute of Technology; Consulting Engineer, Boston, Mass.

*Evening:*
**8.00** ENTERTAINMENT—(Imperial Ballroom)—
For Members and Guests including Ladies. Buffet Refreshments will be served. Informal.
Tickets are Free to Members. Each Member may apply for One Free Ticket for a Lady. Additional guest tickets may be purchased for $1.00 each.
*Tickets should be obtained by 2.00 p.m. on Wednesday.*

## THURSDAY—OCTOBER 7th—

### SOIL MECHANICS AND FOUNDATIONS DIVISION

*Morning and Afternoon*—(Georgian Room)—
*Chairman*—CARLTON S. PROCTOR, M.Am.Soc.C.E.

10.00 **The Objects of the Division and Work Proposed**
CARLTON S. PROCTOR, Director, Am.Soc.C.E., Chairman of Division; Consulting Engineer, New York.

10.15 **Applications of Soil Mechanics to Design of Levees in the Lower Mississippi Valley.**
SPENCER J. BUCHANAN, Assoc.M.Am.Soc.C.E., U. S. Waterways Experiment Station, Mississippi River Commission, Vicksburg, Miss.
Discussion opened by CHARLES SENOUR, Principal Engineer, Mississippi River Commission, Vicksburg, Miss.
THEODORE T. KNAPPEN, M.Am.Soc.C.E., Consulting Engineer, New York.

11.15 **An Investigation of the Stability of Embankment Foundations.**
BENJAMIN K. HOUGH JR., Jun.Am.Soc.C.E., U.S. Engineer Office, Ithaca, N.Y.
Discussion opened by S. C. HOLLISTER, M.Am.Soc.C.E., Associate Dean, College of Engineering, and Director, School of Civil Engineering, Cornell University, Ithaca, N.Y.; L. F. HARZA, M.Am.Soc.C.E., Consulting Engineer, Chicago, Ill.

*Recess for Luncheon*

2.00 **Application of Soil Mechanics to Building Foundations.**
ARTHUR CASAGRANDE, Assoc.M.Am.Soc.C.E., Assistant Professor of Soil Mechanics, Harvard University, Cambridge, Mass.
Discussion opened by DONALD W. TAYLOR, Assoc.M.Soc.C.E., Research Associate, Soil Mechanics, Department of Civil and Sanitary Engineering, Mass. Institute of Technology, Cambridge, Mass.; FRANK A. MARSTON, M.Am.Soc.C.E., Consulting Engineer, Boston, Mass.

3.00 **Review of the Science of Soil Mechanics,** Outlining Particularly Tests and Studies Now in General Use in Connection with Investigations of Soil Mechanics.
GLENNON GILBOY, Assoc.M.Soc.C.E., Associate Professor of Soil Mechanics, Mass. Institute of Technology, Cambridge, Mass.
Discussion opened by PHILIP C. RUTLEDGE, Associate Professor of Civil Engineering, Purdue University, Lafayette, Ind.; D. M. BURMISTER, Assoc.M.Soc.C.E., Assistant Professor, Civil Engineering, Columbia University, N.Y.

4.00 **General Technical Discussion—Methods of Boring and Sampling.**
*Chairman*—WM. P. KIMBALL, Assoc.M.AmSoc.C.E., Assistant Professor, Thayer School of Civil Engineering, Hanover, N.H.
Discussion opened by HENRY A. MOHR, Assoc.M.Am.Soc.C.E., Waban, Mass.

### SANITARY ENGINEERING DIVISION

*Morning*—(Parlor A)—
*Chairman*—ARTHUR D. WESTON, M.Am.Soc.C.E.

10.00 **Studies of the Pollution of Boston Harbour and Its Tributary Waters.**
ARTHUR D. WESTON, M.Am.Soc.C.E., Chief Engineer and Director, Division of Sanitary Engineering, Massachusetts Department of Public Health, and GAIL P. EDWARDS, Laboratory Co-ordinator, Massachusetts Department of Public Health, Boston, Mass.
Discussion opened by E. SHERMAN CHASE, M.Am.Soc.C.E., Consulting Engineer, Boston, Mass.; RAYMOND R. RIBAL, Assoc.M.Am.Soc.C.E., Office Engineer, City of Oakland, Calif.; RICHARD H. GOULD, M.Am.Soc.C.E., Engineer in Charge, Sewage Disposal and Intercepting Sewers, Department of Sanitation, N.Y.

11.00 **The Decomposition of River Deposits.**
GORDON M. FAIR, M.Am.Soc.C.E., Professor of Sanitary Engineering, Harvard University, Cambridge, Mass.
Discussion opened by LANGDON PEARSE, M.Am.Soc.C.E., Sanitary Engineer, Chicago, Ill.

### SURVEYING AND MAPPING DIVISION

*Morning*—(Parlor B)—
*Chairman*—WILLIAM BOWIE, M.Am.Soc.C.E.

10.00 **Land Registration in Massachusetts.**
CLARENCE B. HUMPHREY, Engineer, Massachusetts Land Court, Boston, Mass.
Discussion opened by RAYMOND C. ALLEN, M.Am.Soc.C.E., Civil Engineer, Manchester, Mass.

11.00 **The Establishment of the Massachusetts System of Rectangular Coordinates.**
E. C. HOUDLETTE, Engineer, Mass. Department of Public Works; Director, Mass. Geodetic Survey, Works Progress Administration, Boston, Mass.
Discussion opened by HERMAN J. SHEA, Instructor, Civil Engineering Department, Massachusetts Institute of Technology, Cambridge, Mass.

### 10.00 ENGINEERING-ECONOMICS AND FINANCE DIVISION

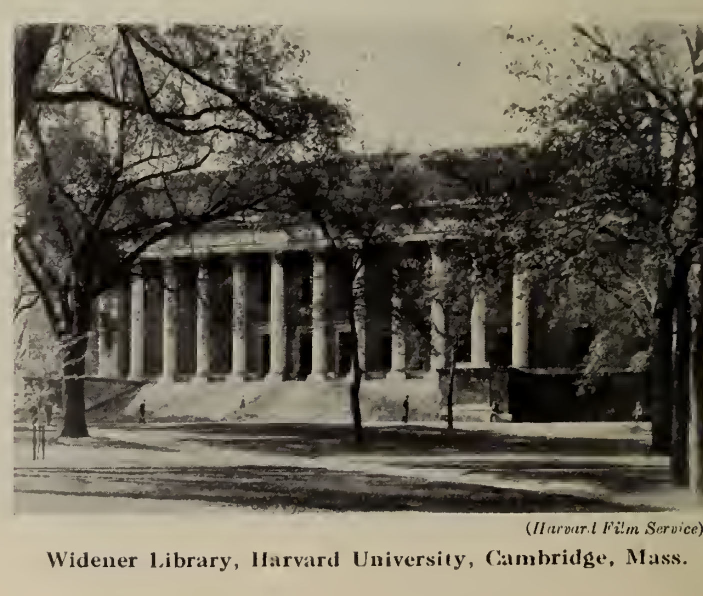
*Morning and Afternoon*—(Parlor C)—
*Chairman*—EDWIN F. WENDT, M.Am.Soc.C.E.

**Hazards of Uneconomic Public Works Construction.**
HENRY EARLE RIGGS, M.Am.Soc.C.E., Hon. Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich.
Discussion opened by WILLIAM J. WILGUS, Hon.M.Am.Soc.C.E., Consulting Engineer, Ascutney, Vt.

*Recess for Luncheon*

2.00 **Engineering-Economics and Public Opinion.**
DANIEL W. MEAD, Past President, Hon.M.Am.Soc.C.E., Professor Emeritus, Hydraulic and Sanitary Engineering, University of Wisconsin; Consulting Engineer, Madison, Wis.

3.00 **Economic Advantages of Orderly Planning of Public Works.**
FREDERIC H. FAY, M.Am.Soc.C.E., Consulting Engineer, Boston, Mass.



(*Harvard Film Service*)

Widener Library, Harvard University, Cambridge, Mass.

(*Harvard Institute of Geographic Exploration*)

Mass. Institute of Technology, Cambridge, Mass.

**Waterways Division**

*Afternoon*—(Parlor B)—

*Chairman*—W. G. Atwood, M.Am.Soc.C.E.

**2.00 Recent Developments in Marine Borer Studies.**
Dr. William F. Clapp, Consulting Biologist, Duxbury, Mass.
Discussion opened by A. H. Morrill, M.Am.Soc.C.E., Chief Engineer, Boston & Maine and Maine Central Railroads, Chairman, New England Committee on Marine Piling Investigation; Francis L. Sellew, District Waterways Engineer, Mass. Department of Public Works; John N. Ferguson, M.Am.Soc.C.E., District Waterways Engineer, Mass. Department of Public Works, Boston, Mass.

**3.00 Repairs of Sub-Structure, Army Supply Base, Boston.**
Major Robert L. Miller, U.S.A., Construction Quartermaster.
Discussion opened by George L. Mirick, Senior Engineer, Construction Division, Quartermaster Corps, U.S.A.

**4.00 Reconstruction of the Deck and Footings of Commonwealth Pier 5, Boston, Mass.**
Charles M. Spofford, M.Am.Soc.C.E., Consulting Engineer, Boston, Mass.
Discussion opened by John Ayer, M.Am.Soc.C.E., Consulting Engineer, Boston, Mass.; C. J. O'Donnell, Resident Engineer, Mass. Department of Public Works., Boston, Mass.

**City Planning Division**

*Afternoon*—(Parlor A)—

*Chairman*—Harold M. Lewis, M.Am.Soc.C.E.

**2.00 The Value of a Thoroughfare Plan and Its Relation to Metropolitan Systems Serving Urban Areas.**
Frank H. Malley, Assoc.M.Am.Soc.C.E., Acting Secretary, Boston City Planning Board, Boston, Mass.
Discussion opened by A. B. Edwards, M.Am.Soc.C.E., Engineer, Mass. Division of Metropolitan Planning, Boston, Mass. The paper will be followed by a discussion on some phases of state planning of interest to civil engineers.

*Evening:*

**7.00** Dinner and Dance—(Imperial Ballroom)—
*Presiding*—Professor Edward L. Moreland, M.Am.Soc.C.E.; Head of Department of Electrical Engineering, Mass. Institute of Technology, Cambridge, Mass., and Consulting Engineer, Boston, Mass.
*Speaker*—Professor Robert Emmons Rogers of the Massachusetts Institute of Technology.
Dancing until 1.00 a.m. Music by Marshard's Orchestra.
Tickets for Dinner and Dance $3.00 each.
Dinner Dress.

## EXCURSIONS ON FRIDAY FOR MEMBERS AND GUESTS

*Several trips are planned for Friday Morning all ending with a "get-together" Shore Dinner at 1.30 p.m. at the New Ocean House at Swampscott where the afternoon will be devoted to recreation. In addition several optional all-day trips to visit engineering projects at a considerable distance from Boston will be arranged if a sufficient number wish to attend.*

**FRIDAY, OCTOBER 8th**—

*Morning and Afternoon:*

**9.00** Buses leave the Columbus Avenue entrance of the Hotel Statler for Harvard University and the Massachusetts Institute of Technology. (Buses for the alternate North Shore Trip leave at 10.30 a.m. from the same place.)

**9.30 to 11.15** **Inspection at Harvard University.**
Two trips are planned with competent guides, one for those wishing to inspect the engineering laboratories where methods of testing soils will be demonstrated in the Soil Mechanics Laboratory and the other for those who wish to visit the Widener Library, the Glass Flowers, and other points of interest.

**9.30 to 11.15** **Inspection at the Massachusetts Institute of Technology.**
The following laboratories of particular interest to civil engineers will be open for inspection: Sanitary Engineering, Seismology, Cement Research, Building Material Research, Soil Mechanics, and River Hydraulics (including an operating model of the Cape Cod Canal). Special arrangements can be made by those desiring to visit other features at M.I.T.

**10.30** **North Shore Trip.**
Buses leave the Columbus Avenue entrance of the Hotel Statler for a motor trip along the North Shore, visiting Revere Beach, Nahant, and Marblehead, terminating at New Ocean House at 1.30 p.m. for the Shore Dinner. This is an alternate trip planned for those who do not wish to visit Harvard or M.I.T.

**11.15** Bus leaves Harvard University (from gate at the Harvard Yard on Broadway opposite Memorial Hall) for M.I.T.

**11.30** Demonstration of "High-Speed" Motion Pictures by Prof. H. F. Edgerton in Eastman Lecture Hall (Room 6-120) M.I.T.

**12.30** Buses leave M.I.T. (from entrance directly outside Eastman Lecture Hall) for Swampscott, Mass.

**1.30** **"Get-Together" Shore Dinner at the New Ocean House, Swampscott.**

**4.30** Buses leave for the Hotel Statler. If a sufficient number desire to make an earlier return to Boston, arrangements will be made for one or more buses to leave the New Ocean House at 3.30 p.m.

*Tickets for the Shore Dinner, including transportation, are $3.00 each. These should be obtained at the Registration Desk not later than Thursday, October 7th.*

**Optional Trips on Friday, October 8th**

These will be arranged provided a sufficient number desire to attend.

Trip to the **Chelmsford Granite Quarries** and to the **Locks and Canals at Lowell, Mass.,** with **Shore Dinner at Swampscott.**
This trip will provide an opportunity to visit the granite quarries of the H. E. Fletcher Co. at West Chelmsford and the works of the Proprietors of Locks and Canals on the Merrimack River. At Chelmsford there will be an opportunity of viewing modern methods of quarrying granite using rotating core cutters, four feet in diameter, to release the pressure and place the material in a free state so that it may be split into sizes which can be handled by derricks. At Lowell may be seen the original drawings and models of apparatus designed by such early New England hydraulicians as James B. Francis and Uriah A. Boyden. Transportation will be by private automobiles, leaving the Hotel Statler (Columbus Ave. entrance) at 9.00 a.m. Tickets, including the Shore Dinner at Swampscott, $3.00. (This trip will be available only for those desiring to attend the Shore Dinner at Swampscott.)

Trip to **Cape Cod Canal.**
This will be an all-day trip. Items of interest are the three new bridges over the canal which have been completed recently, and the widening and straightening of the canal including dredging operations now under way.

Trip to **Quabbin Reservoir,** Boston Metropolitan District Water Supply Project.
This will be an all-day trip. Points to be visited will include the completed control works for the diversion of the Ware River water and the earth fill dam, now under construction by hydraulic sluicing methods, at the Quabbin Reservoir on the Swift River.

Note.—*These optional inspection trips will be arranged only if a sufficient number signify their desire to attend. Names should be left at the Registration Desk on Wednesday, October 6th.*

## ENTERTAINMENT FOR THE LADIES

**Ladies' Headquarters.**
The Library on the Mezzanine Floor of the Hotel Statler will be reserved for the exclusive use of the ladies attending the Meeting. Representatives of the Ladies Committees will be in attendance to be of service to the visitors.

*Morning:*

**10.00 WEDNESDAY, OCTOBER 6th—**

**Opening Session** in the Imperial Ballroom. Ladies will be welcome.

*Afternoon:*

**2.00 Visit to Isabella Stewart Gardner Museum.**
An Art Collection of unique interest. During the visit there will be a talk by the Director and music. Tea will be served. The party will leave the Columbus Avenue entrance of the Hotel Statler at 2.00 p.m.; transportation will be by buses. Tickets may be obtained at the Registration Desk, without charge.

*Evening:*

**8.00 Entertainment**—(Imperial Ballroom)—
Ladies are invited to attend the Entertainment for Members and Guests.

**THURSDAY, OCTOBER 7th—**

*Morning and Afternoon:*

**10.00 Motor Drive** to Lexington and Concord with Luncheon at the Wayside Inn, old-time hostelry made famous by Longfellow and restored and now owned by Henry Ford.
Transportation will be by buses, leaving the Columbus Avenue entrance of the Hotel Statler at 10.00 a.m. Buses returning from Wayside Inn will arrive at the Hotel Statler about 5.00 p.m. Free tickets for the trip and luncheon will be limited to one lady for each registered member of the Society and of The Engineering Institute of Canada. Additional tickets may be obtained at $2.00 each.
*Tickets for this trip should be secured at the Registration Desk before 5.00 p.m. on Wednesday, October 6th.*

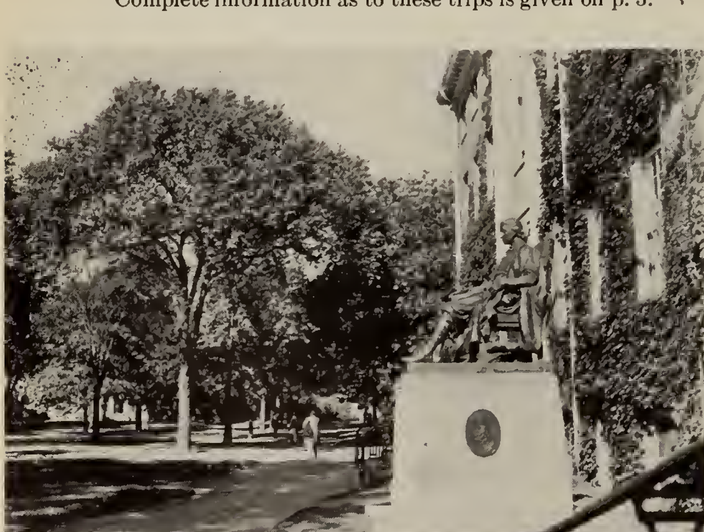
*Evening:*

**7.00 Dinner and Dance**—(Imperial Ballroom)—
Professor Robert Emmons Rogers of the Massachusetts Institute of Technology will be the after-dinner speaker. There will be dancing until 1.00 a.m. See p. 3.

**FRIDAY, OCTOBER 8th—**

*Morning and Afternoon:*

Ladies are invited to attend the **Trips** which are to take place on Friday. Several different trips are planned—terminating at the New Ocean House at Swampscott for a "Get-Together" Shore Dinner.
Complete information as to these trips is given on p. 3.



(*Harvard Film Service*)

**John Harvard Statue, Harvard University, Cambridge, Mass.**

## HOTEL ACCOMMODATIONS AND ANNOUNCEMENTS

In order to be certain of accommodations, members are *urged to make definite arrangements for rooms at least a week in advance* of the Fall Meeting, paying for the rooms in advance for at least a part of the period which they expect to be in Boston.

HOTEL RATES

| | Single Room | Double Room |
|---|---|---|
| Statler Hotel | $3.50 up | $5.00 up |
| Bellevue Hotel* | 3.00 up | 4.00 up |
| Bradford Hotel | 2.50 up | 4.00 up |
| Copley Hotel | 4.00 up | 6.00 up |
| Parker House | 3.00 up | 4.50 up |
| Ritz Carlton | 4.00 up | 7.00 up |
| Touraine Hotel* | 3.00 up | 4.50 up |
| Westminster Hotel* | 2.50 up | 3.50 up |

The rates quoted are the prices per day for a room with private bath. Hotels marked with an asterisk (*) also have rooms without private bath at lower rates.

The Hotel Statler is the meeting headquarters, and it is expected that it will be able to care for all who attend. This hotel is located at Arlington Street and Columbus Avenue, near Park Square.

*Reservations are to be made directly with the hotel.* Hotel will make acknowledgment of reservation direct to member.

All who attend the Fall Meeting are requested to register immediately upon arrival at meeting headquarters, Mezzanine Floor of Hotel Statler. Special badges and tickets will be obtained at the time of registration.

## RAILWAY ARRANGEMENTS

Special convention fares having been discontinued by the American railways, the following are the lowest first class round trip fares to Boston available in October from the Canadian points named; one-way sleeping car (lower berth) rates are also given.

| From: | Round-trip rail fares | Limit | One-way sleeping car charges |
|---|---|---|---|
| Winnipeg | $89.80 | 30 days | $13.75 |
| Windsor, Ont | 46.30 | 1 year | 7.15 |
| Toronto | 37.15 | 1 year | 5.50 |
| Peterboro | 36.80 | 6 months | 5.00 |
| Ottawa | 27.10 | 1 year | (seat) .70 to Montreal. (lower) 2.75 to Boston. |
| Montreal | 20.50 | 1 year | 2.75 |
| Quebec | 25.30 | 1 year | 3.30 via Sherbrooke. |
| Saint John, N.B. | 23.40 | 30 days | 3.30 |
| Moncton | 28.40 | 30 days | 4.15 |
| Halifax | 37.45 | 30 days | 5.50 |
| Sydney | 43.25 | 30 days | 7.75 |

## INFORMATION

A registration Desk will be provided on the Mezzanine Floor of Hotel Statler to assist visiting members in securing any desired information.

## LOCAL COMMITTEES ON ARRANGEMENTS

**Executive Committee**

F. A. Barbour, General Chairman.
F. H. Kingsbury, Secretary.
A. W. Dean, Director, Am.Soc.C.E.
H. A. Gray, Past-President, Northeastern Section, Am.Soc.C.E.
W. R. Benford, representing Providence Section, Am.Soc.C.E.
J. P. Wadhams, representing Connecticut Section, Am.Soc.C.E.
F. A. Marston, Chairman, Sub-Committee on Technical Program.
F. M. Gunby, Chairman, Sub-Committee on Finance.
Albert Haertlein, President, Northeastern Section; Chairman, Sub-Committee on Hotel and Registration.
J. B. Babcock, Chairman, Sub-Committee on Entertainment and Service.

**Ladies Committee**

Mrs. F. E. Winsor, Chairman.

| | |
|---|---|
| Mrs. F. A. Barbour | Mrs. C. B. Breed |
| Mrs. A. W. Dean | Mrs. H. P. Eddy |
| Mrs. S. M. Ellsworth | Mrs. F. M. Gunby |
| Mrs. Albert Haertlein | Mrs. R. K. Hale |
| Mrs. E. H. Rogers | Mrs. C. M. Spofford |

**Engineering Institute Committee**

Detail arrangements for the participation of The Engineering Institute of Canada were placed by the Council in the hands of a committee consisting of

Past President J. M. R. Fairbairn, Convenor.
Past President E. A. Cleveland
and Past President F. P. Shearwood

These gentlemen co-operated with the Boston Executive Committee in respect to the arrangements for the Joint Meeting.

## The Future of the Airship

As a consequence of the tragic end of the famous German airship the *Hindenburg*, the attention of the public and that of every serious student of aeronautics has once more been directed to the yet undecided question of long-distance flight, whether the future lies with the airship or with the aeroplane. The disaster to the *Hindenburg* may or may not prove more than a temporary setback. Travel by airship will certainly lose popularity for the time being, but as concerns the future, much will depend upon the result of the investigation now taking place; for the present that aspect of the subject may be dismissed in a few words.

Whatever may have been the immediate cause of the disaster, the only fact so far disclosed is that it was due to fire and not to any structural defect. If helium had been used in place of hydrogen, it is fair to assume that the airship would not have been lost, although there might have been something in the way of an "incident"; but if the *Hindenburg* had been inflated with helium her buyoancy and her margin of lift would have been reduced by approximately 14 tons, which would represent the loss of a pay-load of the magnitude equivalent to 150 passengers and crew with an allowance of ½ cwt. each for luggage, etc. Bluntly stated, this means that the *Hindenburg* would, for all practical purposes, have ceased to possess any commercial value; and then it would become a question of weight saving, cheeseparing, a bit here and a bit there. The dilemma is the same as that which resulted in the loss of the R.101. In the design and construction of that airship everything possible was said to have been done with the object of making her *safe*. Diesel engines by Messrs. Beardmore were adopted to do away with the danger of petrol; special provision was made in the construction of the hull to enable her to resist bad-weather conditions and to ride out a storm at her mooring post. But these very precautions resulted in the buoyancy being cut too fine; the Diesel engines and some other components came out just a little heavier than expected. A lack of buoyancy in an airship is a fatal defect. It was one of the findings in that particular case that there had been a serious leakage of gas, but that merely exaggerated a defect that would probably have resulted in disaster in any case. When over the Channel there were already signs that the R.101 was deficient in buoyancy, and she should have been ordered back home. It is worthy of remark that had R.101 been filled with helium instead of hydrogen the disaster would not have occurred, because then she would never have left the ground at all; she would have remained safe and sound at Cardington.

In discussing the future of the airship *vis-à-vis* of the aeroplane it would be wrong to make too much of the disasters of the past; a great deal of experience has been accumulated, and doubtless there are many more lessons to be learnt.

On the score of safety, we may assume that the aeroplane of the future will be driven by not less than four engines of sufficient power to render the plane safe to fly with any one engine out of commission. Such machines exist to-day. On a large machine it is further possible to make provision for the rectification of minor defects while in the air; this means that a breakdown involving a forced landing would be a very rare occurrence. It is already recognized that the Diesel type of engine for flights of long duration has the advantage of the additional deadweight being more than compensated by the economy and saving of weight in fuel; thus the danger from fire is practically eliminated, or at least reduced to very small proportions. The stages flown over long stretches of water could be negotiated by flying boats, which if brought down could be navigated under favourable conditions or would remain afloat for a considerable time in bad or stormy weather. There is no necessity for the one type of machine to be used on the different stages of a long-distance flight. An aeroplane capable of making a passage at something over 200 m.p.h. would not be at the mercy of the wind as would an airship with less than half that flight speed; and there is no prospect that the speed of the airship can be increased beyond 100 m.p.h. unless its size be increased substantially beyond what it is to-day. And even as things stand, the possibility of total loss is a very considerable risk; an airship, if from any cause it is unable to remain in the air, is almost certain to meet with disaster unless by good fortune it is in the vicinity of a mooring post and able to call up the requisite crew to effect a safe landing.

In view of the above, the writer feels very doubtful whether the airship has any prospect of a commercial future at all.—Dr. F. W. Lanchester, F.R.S., in *Engineering.*

## Steel Wire for Bridge Cables

Although wire-drawing was already an established industry at Tintern in Elizabethan times, it was not until 1854, when James Horsfall discovered the effect of controlled rate of cooling and invented the process that is still known in the trade as "patenting," that cold-drawn steel wire came into general use for ropes. The "patenting" process produces in the steel an exceedingly fine sorbitic structure of remarkable ductility that facilitates cold-drawing and thereby enables great tensile strength to be gained in association with the toughness that is characteristic of roping wire. Nearly all the steel wire that is now used in ropes and in bridge cables is cold-drawn with a number of passes after some form of patenting process. A certain amount of bridge wire in recent years has been heat-treated still more drastically, by quenching in an oil-bath, to give the full tensile strength required without any subsequent reduction of cross-sectional area by cold-drawing. Wire that has been hardened in this manner, by oil-quenching instead of by cold drawing after patenting, is known as "heat-treated" and has been used to some extent in important suspension bridges in the United States.

Interesting cases of failure of heat-treated wire occurred in the cables of the Mount Hope Bay bridge between Bristol and Portsmouth, R.I., and also in the slightly longer Ambassador bridge which, about the same time, was under construction across the Detroit river. The cables of these two bridges were dismantled before the completion of the structures and were replaced by new cables of cold-drawn wire. The failure of heat-treated wire in the Mount Hope bridge in particular has been recently investigated in a characteristically thorough manner by the National Bureau of Standards, Washington; and a detailed description of this work and of the circumstances that led up to it is contained in a paper by W. H. Swanger and G. F. Wohlgemuth, now published by the American Society for Testing Materials. The paper has been awarded the Charles B. Dudley medal of the Society and is of outstanding interest to bridge builders and to all interested in wire ropes.

The authors give a detailed account of the failure of the heat-treated wires in the cable anchorages of the Mount Hope bridge. In February, 1929, several months after the completion of the spinning of the parallel wires in position in the cables, but before the completion of the bridge structure, fractures were discovered in the wires where they had been bent to form loops round the cast-steel shoes pin-jointed to the eye-bars of the anchorages. The wires were of 0.195 in. diameter and the shoes of 19½ in. diameter, and all the fractures occurred at or near to the points of tangency on the shoes. Attempts were made to replace the first few broken wires, but further fractures developed more rapidly than they could be replaced.

The cause of the brittleness was traced to the surface condition of the galvanized heat-treated wire. A large group of samples was assembled to contain those in which the proportion of brittle fractures was higher than usual, and it was found that the proportion could be much reduced by polishing the surface after the layer of zinc had been removed by acid. When the outer surface was removed mechanically to a depth of 0.015 in., all low-reduction breaks were eliminated. Further classification endorsed the conclusion that the brittleness was due to deeply-seated defects, occurring sporadically, but apparently throughout the whole of the heat-treated wire. The nature and origin of the deep-seated defects was investigated micrographically with reference to the process of manufacture.

The authors express the opinion that the defects originated from pits formed where mill-scale and other rolling defects had not been ironed out during the one or two draws that brought the wire to size before heat-treatment, these pits being possibly enlarged in the pickling bath that preceded the galvanizing. But if this were the only explanation, it seems difficult to understand why cold-drawn wire should be so consistently free from the same trouble. The profiles of the defects appear decidedly reminiscent of the grain structure, and it seems not unlikely that they formed as cracks during quenching or, alternatively, that they may have formed during the galvanizing process by the intrusion of zinc between the grains of metal subject to tension. In view of work that has been done in England, the point is one that seems to merit further investigation.—*Engineering.*

## Canadian Air Transport

According to statistics just received for 1936, the 43 companies engaged in air mail and freight transport in Canada showed a substantial increase in business over 1935; no less than 43 per cent in the case of ordinary commercial freight, namely 11,272 tons, while air mail reached a new high level of 1,153,812 lb. Canadian Airways is the largest operating company, with a freightage last year of 7,750,000 lb., followed by Starratt Airways with 3,600,000 lb., and Wings, Limited, with 2,232,000 lb. These three companies between them used 53 aircraft of seven different types. Much of the business is, of course, associated with Canada's leading industry of mining, and in one contract carried out by Wings, Limited, it involved the transport of an entire mining plant from a point 325 miles east of Lake Winnipeg to a new mining site just over the Ontario boundary—a distance of 145 miles. The total weight of cargo was more than 600,000 lb., and included a mine hoist, a mine cage, sinking buckets, rock drills and steel, eight ore cars, 60,000 lb. of dynamite, 70 workmen and their belongings, and some 35 tons of foodstuffs. Special air bases, with radio stations, were established at both ends of the run. Some of the machinery to be moved raised difficult problems owing to weight and bulkiness. The compressor when assembled weighed 14,000 lb., and the hoist 4,600 lb. The sub-base of the compressor was 15 ft. long; it was cut in two and reassembled at the new site, each piece weighing ½ ton. Two tractors weighing, respectively, 6,250 lb. and 5,700 lb. were also sent in sections. Canadian fisheries also find air transport of great value. One company alone—United Air Transport, with headquarters at Edmonton—conveyed more than 1,000,000 lb. of fish during the past winter. An interesting experiment is that of re-stocking small lakes with fish by means of aeroplanes; this is said to have proved successful.—*Engineering.*

## Ground-line Preservation of Wood Poles

Transmission problems, in connection with telegraph, telephone and electricity supply, call for constant maintenance, not the least of which is connected with the use of wooden poles for carrying wires and cables. The greatest trouble with these is experienced at or just below ground level. A method practised in Ontario of protecting this region with a view to prolonging the life of such poles was described in a paper read before the Association of Municipal Electrical Utilities at Toronto, early this year, and given in a recent issue of the *Bulletin* of the Hydro-Electric Power Commission of Ontario.

The preventive measures are the result of experience dating back to the year 1920, which fully establish the value of coal-tar creosote.

It is with a view to saving the hot and cold dipping, applied either at some central depot or *in situ*, that the bandage or collar method of treatment now favoured has been adopted for both new and old poles. The collars employed provide a setting equal in strength to the surrounding earth and also make for easy re-treatment, without excavation, when and if required. They also prevent loss of creosote by the pole treated and retard its absorption of moisture from the area of soil surrounding it. Capillary action within the sap wood is relied upon to carry the applied creosote in both directions vertically. Galvanized sheet iron is employed, loosely wrapped round the pole and secured by wire, then lowered into position and radially extended by means of wooden, tapered wedges. The sheet iron joint is secured by nails, at the overlap, to one of the wedges which is permanent. The annular space is then filled with sand and the temporary wedges are withdrawn. After the application and absorption of the creosote, the job is completed by filling up the collar to the brim with a mixture of sand saturated with creosote, to form a seal. Experiments have proved that the eighteen-inch column of sand holds, according to its fineness, 20 per cent to 25 per cent of its volume of creosote. Approximately three-quarters of this is absorbed, in the case of cedar, and the remainder is relied upon to inhibit fungus growth.

Wastage of creosote which might otherwise occur, due to its leakage pending absorption, is prevented by placing the tightening wire close to the bottom of the sheet and allowing the wooden wedges to exert their pressure against that portion of the sheet above it. About half a gallon of creosote per pole, of cedar, is a good allowance, and reliance is placed upon the crust formed by the finishing top layer of sand saturated with creosote to prevent loss of loose sand by wind or by rain.—*Engineering.*

## The Vibrations of Airscrew Blades

Engineers seldom have a good word to say for vibration. Decrease in the weight of material and a corresponding increase in the working stresses have, however, resulted in the subject becoming a matter of importance when factors of safety are comparatively low. Certain parts of aircraft present outstanding examples of this, since the need for economy of material has led to slender structures which are in this connection extremely sensitive to the periodic forces produced by aero engines in particular. The stress on the blades of an airscrew, for instance, may well be increased to four or even five times the normal value if the torsional deformation on the crankshaft amounts to a degree or so of arc, under conditions of resonance. Such an increase of stress calls for due consideration in view of the usual factors of safety employed in this class of construction. But there is more to be said on the point, for most objectionable noises can in general be caused when only small amplitudes of vibration are involved, and this adversely affects the measure of comfort of aerial transport. Though but different forms of periodic disturbance, vibration and noise require separate consideration with reference to the remedial measures to be taken. This is so because both the phenomena affect the passengers and pilots, but the former tends further to the development of undesirable stresses in the structure concerned, as already pointed out. While certain types of oscillation arise mainly from aerodynamical sources, others are induced by the mechanical effect of the unbalanced forces and couples associated with aero engines. This may or may not cause the principal parts of the system, such as the fuselage and airscrew, to execute large vibrations, since the motion depends partly on the conditions that make for resonance, and partly on the amount of energy involved in the disturbance.

The failure of propellers on this account is a comparatively rare occurrence in this country, but the few instances on record nevertheless suffice to emphasize the need for an examination of the contributory factors. The subject is of special interest to engineers on account of the fact that the engine is the principal source of disturbance in certain circumstances, due to variations in the driving torque being transmitted by way of the shaft to the airscrew. This is only one aspect of the problem presented by actual blades, for their form renders them liable to complicated oscillatory motion, even when the machine is making a straight course, as was demonstrated recently by Major B. C. Carter before the Royal Aeronautical Society, in a paper entitled "Airscrew Blade Vibration." The information contained in this contribution to the subject amplified our knowledge on an extremely difficult matter, in so far as the experimental work was based on the fact that the crankshaft and propeller vibrate as a structural unit.

—*Engineering.*

# RECENT ADDITIONS TO THE LIBRARY

### Proceedings, Transactions, etc.

American Society of Mechanical Engineers: Transactions, Vol. 59, No. 6. Aug. 1937.

New Zealand Society of Civil Engineers: Proceedings 1936-7, Vol. 23.

Institution of Mechanical Engineers: List of members, May 1937.

Institution of Civil Engineers: List of members, July 1937.

Institution of Civil Engineers: The Laws of a Mass of Clay Under Pressure, Maurice Augustus Ravenor, M.I.C.E. 1937.

International Conference on Large Electric High-Tension Systems: Precision Measurements to Determine the Dynamic Characteristics of Suspension Insulators. June 24 to July 2, 1937.

### Reports, etc.

*Interdepartmental Montreal and Ship Channel Water Levels Board:* Report and a Memorandum re The Economic Value of Raising Water Levels or Increasing Depth in the Harbour of Montreal by D. W. McLachlan, M.E.I.C.

*American Institute of Steel Construction:* Stress Distribution in Steel Rigid Frames. Progress Reports, Nos. 6-8, 1937.

*United States, Department of the Interior, Office of Education:* Graduate Work in Engineering in Universities and Colleges in the United States, Walton C. John and H. P. Hammond. Bulletin 1936, No. 8.

*Institute of the Aeronautical Sciences:* Bibliography of Aeronautics. pt. 4—Dynamics of the Airplane; pt. 17—Diesel Aircraft Engines; pt. 29—Lubricants; pt. 47—Women in Aeronautics; pt. 49—Rocket Propulsion; pt. 50—Stratospheric Flight. (Works Progress Administration.)

*Bell Telephone System:* Technical Publications, Monographs B-978-997. (*Presented by Northern Electric Company Limited.*)

*International Nickel Company:* Heat Treatment Fundamentals of Nickel Cast Iron, Plain Cast Iron, Nickel-Chromium Cast Iron, Nickel-Chromium-molybdenum Cast Iron. No. 7, section 3.

*International Nickel Compony, Development and Research Division:* Nickel and Its Alloys.

### Technical Books

The Story of Telford, the Rise of Civil Engineering, Sir Alexander Gibb. 1935. (*Presented by Sir Alexander Gibb, M.E.I.C.*)

Confessions of an Engineer by Sir Alexander Gibb. (The Nineteenth of the Broadcast National Lectures, Jan. 29, 1937.) (*Presented by Sir Alexander Gibb, M.E.I.C.*)

The Collected Papers of Rhys Jenkins, comprising articles in the professional and technical press mainly prior to 1920 and a catalogue of other published work. 1936. (*Presented by the Newcomen Society.*)

Petroleum, Twenty-five Years Retrospect 1910-1935. (*Institution of Petroleum Technologists, London.*)

Swiss Export Directory, Directory of Swiss Manufacturers and Producers, 1937. (*Swiss office for the Development of Trade, Zurich.*)

# BULLETINS

*Turbine Pumps.*—A 6-page bulletin has been received from the Roots-Connersville Blower Corporation, Connersville, Indiana, describing the construction of their Type T turbine pump.

*Milling Machines.*—Brown & Sharpe Mfg. Co., Providence, R.I., in a 4-page bulletin give particulars of their No. 12 electrically controlled plain milling machine.

*Convection Heaters.*—A 6-page bulletin from Trane Company of Canada Limited, illustrate their floor and wall-hung cabinet type heaters.

*Expansion Joints.*—Stainless steel S type expansion joints are described in a 10-page booklet which has been received from the Foster Wheeler Corporation, St. Catherines, Ont. With suitable modifications these joints are good for operating pressures of 300 lb. per sq. in. and temperatures of 700 deg. F.

*Group-Operated Switches.*—General Electric Company of Canada, Toronto, in a 4-page bulletin describe their type TC group-operated switch, a moderate duty vertical-break switch for outdoor use, 7.5 to 46 kv.—200 amperes.

*Magnetic Clutches.*—The Northern Electric Company, Montreal, give particulars of their C-H magnetic clutches sizes 3 to 78 in. in a 4-page leaflet.

*Arc Welding.*—A 14-page booklet recently prepared by the Lincoln Electric Company gives particulars of the arc welding process as applied to the construction of pipe lines.

*Pipe Fittings.*—The Dresser Manufacturing Company, Toronto, Ont., have issued a catalogue announcing a standard line of style 65 fittings which eliminates the necessity of pipe threading. The complete line of these fittings includes: standard and extra-long couplings, ells (both 45° and 90°), and tees, all supplied in standard steel pipe sizes from ½ in. I.D. to 2 in. I.D., inclusive, black or galvanized.

# Preliminary Notice

## of Applications for Admission and for Transfer

August 20th, 1937

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.*

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

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The Council will consider the applications herein described in October, 1937.

R. J. Durley, Secretary.

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*The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years in the case of a candidate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of age, and shall have been engaged in some branch of engineering for at least six years, which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch of engineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more years.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard.

**A Student** shall be at least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

> The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.

### FOR ADMISSION

BEAVER—HUGH EYRE CAMPBELL, of London, England., Born at Johannesburg, South Africa, May 4th, 1890; Educ., Wellington College, 1904-10; Member, Inst. Chem. Engrs.; Fellow, Royal Economic Society and Royal Statistical Society; 1910-21, in service of Punjab Govt., India; 1922-30, on the staff, and 1931 to date, partner in the firm of Sir Alexander Gibb and Partners, London, England. Work included: 1931, head of mission under Sir Alexander Gibb to report on Canadian national ports; reconstrn. of West Side of Saint John Harbour; layout and constrn. of Messrs. Guinness' brewery, factory and industrial estates; consulting engr. to Commissioner for Special Areas; also reports and preparation of various large industrial development schemes.

References: Sir Alex. Gibb, J. M. R. Fairbairn, C. H. Mitchell, A. G. L. McNaughton, E. A. Cleveland.

BRYCE—JOHN BEMISTER, of 2 Highview Crescent, Toronto, Ont., Born at Toronto, Jan. 1st, 1913; Educ., B.A.Sc., 1935, M.A.Sc., 1936, Univ. of Toronto; With the H.E.P.C. of Ontario as follows: Summers 1935-36, power house operator, and Aug. 1936 to date, junior engr., hydraulic dept.

References: O. Holden, R. W. Angus, J. J. Traill, S. W. B. Black, J. R. Montague.

McLAUGHLIN—WILLIAM GORDON, of Cumberland, Ont., Born at Cumberland, Sept. 16th, 1910; Educ., B.S.c. (Mech.), Queen's Univ., 1934; M.E. (Mech.), Rensselaer Polytech. Inst., 1936; 1934-35, demonstrator, dept. of mech'l. engrg., Queen's Univ.; 1936-37, technical dept., E. B. Eddy Co. Ltd., Hull, Que., and April 1937 to date, constrn. of bleach sulphite plant for same company.

References: W. S. Kidd, A. N. Ball, L. M. Arkley, L. T. Rutledge, D. W. McLachlan.

RAMSAY—WILLIAM WALLACE, of Elbow Lake, Man., Born at Stonewall, Man., July 23rd, 1907; Educ., B.Sc. (C.E.), Univ. of Man., 1933; 1927-28, rodman, 1928-30, instr'man., Man. Good Roads Board; 1936-37, engr., Flin Flon Gold Mines; At present engr., Century Mining Corpn. Ltd., Cranberry Portage, Man.

References: J. N. Finlayson, G. H. Herriot, W. F. Riddell, A. E. Macdonald, E. P. Fetherstonhaugh.

PATRIARCHE—VALANCE HEATH, of 193 Oakwood Ave., Winnipeg, Man., Born at Winnipeg, Dec. 1st, 1907; Educ., B.Sc. (C.E.), Univ. of Man., 1929. Commercial and Military Air Pilot. Air Engr's License; 1925, garage mechanic, Ross Motors, Winnipeg; 1926-28, R.C.A.F. in training; 1928, chairman, road location; 1929-30, junior to senior pilot, Northern Aerial Minerals Exploration Co. Ltd., also in shops of this company, 1929-30; 1930, prlim. water power survey, N.W.T.; 1931-33, senior pilot, Spence, McDonough Air Transport Ltd., in charge of McMurray base; 1933-34, pilot, 1934-35, traffic mgr., and 1935 to date, gen. traffic mgr., Canadian Airways Ltd., Winnipeg, Man.

References: E. P. Fetherstonhaugh, N. M. Hall, G. H. Herriot, F. V. Seibert, A. E. Macdonald.

SEELY—HAROLD CHIPMAN, of 651 Union St., Fredericton, N.B., Born at Saint John, N.B., Jan. 9th, 1901; Educ., B.Sc. (E.E.), Univ. of N.B., 1926; 1926-27, student's course, 1927-28, service engr., and 1928-29, junior erecting engr., Can. Gen. Elec. Co. Ltd.; 1929-31, general plant efficiency work, also designing elect'l. and steam layouts, also supting. elec. constrn. work, Canadian Industries Ltd.; 1931-32, supting. elect'l. constrn. work of the cellophane plant, Shawinigan Falls, for Fraser Brace Engrg. Co.; 1932-34, chief engr. responsible for operation of elect'l. and mech'l. equipment on evening shifts, and 1934-37, gen. mtce. foreman or asst. mtce. supervisor, Canadian Industries Ltd., cellophane plant at Shawinigan Falls, Que.

References: H. C. Karn, G. N. Thomas, H. J. Ward, H. K. Wyman, A. F. Baird.

THEOBALDS—THOMAS REYNOLD, of Castries, St. Lucia, B.W.I., Born at Castries, May 8th, 1903; Educ., B.Sc. (Civil), McGill Univ., 1928; 1927 (summer), labourer, Friedsted Foundation Co., New York; 1928 to date, town engr., to the Castries Town Board, St. Lucia, on constrn. and mtce. of roads and pavements, town drainage, mtce. of municipal bldgs., examining bldg. applications, erecting reinforced concrete and steel girder bridges, reconstrn. and mtce. of pipe lines for water supply, supervising the Castries waterworks generally, and installing a chloramine plant to same.

References: R. DeL. French, R. E. Jamieson, G. J. Dodd, G. E. Shaw, T. R. Durley.

### FOR TRANSFER FROM THE CLASS OF JUNIOR

GILCHRIST—JOHN, of 5551 St. Hubert St., Montreal, Que., Born at Glasgow, Scotland, July 31st, 1907; Educ., B.Sc. (E.E.), Univ. of N.B., 1932; 1922-24, ap'tice., machine shop and drawing office, Barr & Stroud, Glasgow; 1926 (summer), rodman on survey, Dom. Forest Service; 1926-29 (less 7 mos. at univ.), dftsman., International Paper Co.; 1931 (summer), boiler plant survey, E. S. Stephenson Co., Saint John, and concrete inspr.'s asst., Saint John Harbour Commn.; 1932 (summer), instr'man. and asst. engr., City of Saint John; 1933-35, engrg. asst. to plant supt., General Steel Wares, Montreal; 1935 to date, dist. plant engr., Canadian district, Barrett Co., Montreal. (*Jr. 1934.*)

References: E. O. Turner, J. Stephens, A. F. Baird, C. K. McLeod, D. F. Grahame, J. F. Plow.

THOMPSON—FRANK LAWRENCE, of Dartmouth, N.S., Born at Moncton, N.B., Oct. 21st, 1905; Educ., B.Sc. (M.E.), N.S. Tech. Coll., 1932; 1924-26, machinist ap'tice., C.N.R.; 1932-34, gen. work at refinery, and from 1934 to date, technical service engr., for Maritime Provinces and Newfoundland, for Imperial Oil Limited. (*St. 1930.*) (*Jr. 1935.*) .

References: R. L. Dunsmore, C. Scrymgeour, R. R. Murray, H. W. McKiel, J. A. MacKay.

### FOR TRANSFER FROM THE CLASS OF STUDENT

HAWKE—CHARLES EDISON, of 91 St. George St., Toronto, Ont., Born at Moose Jaw, Sask., Dec. 25th, 1908; Educ., B.A.Sc., Univ. of Toronto, 1934; Summer Work: 1926-29, installn. dept., Moose Jaw Heating and Plumbing Co, 1930-31, installn. dept., Northern Electric Co., Montreal; 1935 to date, asst. engr., Toronto district, Dept. of Public Works of Canada, in charge of certain dredging and dock contracts. (*St. 1930.*)

References: J. B. Challies, J. M. Wilson, C. R. Young, R. W. Angus, R. F. Legget.

POWLES—GEORGE AUSTIN, of New Liskeard, Ont., Born at Montreal, Que., Sept. 12th, 1903; Educ., two years high school, corres. course and practical training; 1924-25, chainman, C.P.R.; 1926-27, chainman, 1927-28, topog'r. and levelman, and 1928-29, instr'man., T. & N.O. Rly.; 1929 (Jan.-Aug.), dftsman., Abitibi Power and Paper Co. Ltd.; 1929-37, instr'man., Ontario Dept. of Northern Development, making road and bridge surveys, surveys for drainage, and layout work for structures. and the preparation of plans and estimates for road and bridge surveys; April 1937 to date, instr'man., Ontario Dept. of Highways, doing same work as for Dept. of Northern Development. (*St. 1926.*)

References: S. B. Clement, W. N. Cann, R. M. Smith, T. F. Francis.

## EMPLOYMENT SERVICE BUREAU

The Service is operated for the benefit of members of The Engineering Institute of Canada, and for industrial and other organizations employing technically trained men—without charge to either party.

*All correspondence should be addressed to*

**The Employment Service Bureau, The Engineering Institute of Canada**
2050 Mansfield Street, Montreal

### Situations Vacant

DRAUGHTSMAN, with knowledge of mechanical and electrical drawings. Also familiar with survey drawings. Apply to Box No. 1621-V.

DRAUGHTSMAN, experienced in pulp and paper mill operation and maintenance. Permanent position. Apply to Box No. 1625-V.

MECHANICAL ENGINEER, for plant layout and estimating work and some draughting. Location Montreal. Apply to Box No. 1626-V.

RECENT GRADUATE, for time study work with large industrial company in Montreal. Apply to Box No. 1627-V.

DRAUGHTSMAN, general engineering draughtsman for newsprint mill in Quebec, staff house accommodation. Single man preferred. Must be neat draughtsman and able to make raw material surveys. State age, experience and salary expected, and submit sample of work. Apply to Box No. 1628-V.

MECHANICAL SUPERINTENDENT. General contractor will shortly require mechanical superintendent to supervise mechanical and electrical sub-contract work to cost in excess of one million dollars on large city building construction contract. Man appointed will be expected to relieve office engineer and general superintendent of all details pertaining to mechanical and electrical work. Present contract will last about eighteen months, with possibility of further engagement thereafter. Interesting opportunity for right man. Apply to Box No. 1634-V.

ELECTRICAL AND CIVIL ENGINEER, with some experience, for a town in the province of Quebec. Apply to Box No. 1636-V.

RECENT GRADUATE, in mech. or civil engrg., with some experience in design and draughting. Location Ontario. Apply to Box No. 1637-V.

MECHANICAL ENGINEER, preferably with paper mill experience, but would consider training a young graduate. Apply to Box No. 1639-V.

ELECTRICAL OR MECHANICAL ENGINEER with sales experience, preferably of Swiss nationality, for British India. Apply to Box No. 1640-V.

CHEMICAL ENGINEERS. Young chemical engineer with one or two years experience in pulp and paper mill. Also a recent graduate in chemical engineering. Apply to Box No. 1641-V.

DRAUGHTSMEN. Experienced ship draughtsmen. Salary from $150 to $200 per month depending upon experience. Location Montreal. Apply to Box No. 1642-V.

CIVIL ENGINEER, with experience in connection with bush operations, particularly with reference to construction of dams and piers for holding grounds, small houses and logging equipment, including marine engines, tractors, trucks, saw mills, etc., for a pulp and paper mill in the province of Quebec. Apply to Box No. 1643-V.

MECHANICAL DRAUGHTSMEN. Situations vacant for experienced mechanical draughtsmen. Permanent employment for suitable men. Applications by letter only, giving full particulars of experience. Dominion Engineering Works Limited, P.O. Box 3150, Montreal, Que.

### Situations Wanted

PURCHASING ENGINEER, graduate mechanical engineer, Canadian. Married, with fifteen years experience covering construction and operation, principally having to do with specification and ordering of equipment and materials for new construction and maintenance. Details upon request. Apply to Box No. 161-W.

INDUSTRIAL ENGINEERING EXECUTIVE, with wide experience including fourteen years in design, construction, maintenance and operation of pulp and paper mills and power developments. Now employed, desires change of location. Apply to Box No. 320-W.

CIVIL ENGINEER, B.A.Sc., age 44, structural, harbour, executive. At present designing 32,000-h.p. development in Newfoundland. Available in near future. Apply to Box No. 536-W.

DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aerophotographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.

### Situations Wanted

ELECTRICAL ENGINEER, B.Sc., E.E., age 38. Married. Ten years electrical experience; including, one year operation, one year maintenance, and four years on construction of hydro-electric plants and sub-stations. Four years electric maintenance and construction in pulp and paper mill. Also experience on highway construction and Geological Survey. Available at once. Apply to Box No. 636-W.

ELECTRICAL ENGINEER, B.Sc. E.E. '28. Two years with large electrical manufacturing company including test course, about two years in supervisory operating office of a large electrical power utility, and considerable experience in electrical and mechanical draughting. Location in Ontario preferable. Apply to Box No. 660-W.

YOUNG CIVIL ENGINEER, B.Sc. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

CIVIL ENGINEER, B.Sc., M.Sc., R.P.E.; Lieut. C.E., R.O. 16 years municipal, highway and construction, 5 years overseas. Married. Read, write and talk French. Will go anywhere. Apply to Box No. 737-W.

RADIO AND ELECTRICAL ENGINEER, B.Sc., '31, Jr.E.I.C. Single. Age 30. One year and a half actual field experience in power and lighting equipment. Extensive work in telephone and radio layouts in switchboard and installation depts. Particularly interested and experienced in sales and traffic work in telephone and radio company. At present supervisor over sales and service of radio and electrical company. Available on short notice. Location immaterial. Apply to Box No. 740-W.

PLANT ENGINEER or SUPERINTENDEBT, capable of supervising all phases of industrial plant operation, graduate electrical, eleven years diversified industrial experience including test course, four years on large Quebec industrial development, on construction and operation, also six years with prominent consulting firm supervising electrical and mechanical engineering projects. Age 31, single. Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman, compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

MECHANICAL ENGINEER, Jr.E.I.C., technical graduate, bilingual, age 35, married, experience includes five years with firm of consulting engineers, design of steam boiler plants, mechanical equipment of buildings, heating, ventilating, air conditioning, plumbing, writing specifications, etc. Five years with large company on sales and design of power plant, steam specialties and heating equipment. Available on short notice. Apply to Box No. 850-W.

STRUCTURAL ENGINEER, B.A.Sc., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

ELECTRICAL ENGINEER, B.Sc. (McGill '28), age 34. Experience includes transmission line and rural distribution construction and design. Some installation of motors and equipment, also house wiring. Available immediately. Apply to Box No. 940-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.

ELECTRICAL ENGINEER AND GEOPHYSICIST, B.Sc. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

### Situations Wanted

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No. 1168-W.

ELECTRICAL ENGINEER, B.Sc. '34 (Univ. of N.B.), S.E.I.C. Age 24, single. Desires any kind of electrical work. Will consider any location. Apply to Box No. 1262-W.

ELECTRICAL AND RADIO ENGINEER, S.E.I.C., B.Sc. (Elec.) '32, M.Sc. '34. Experience includes four years part time operator for radio broadcast station, repairs to radio receivers and test equipment, design and construction of amplifiers and inter-office communication systems. Available on short notice. Apply to Box No. 1283-W.

CIVIL ENGINEER, B.Sc. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

CONSTRUCTION SUPERINTENDENT, M.E.I.C. Age 49. Married. Twenty-two years experience as engineer, superintendent and manager in charge of hydro-electric, mechanical production, structural steel erection, also considerable experience in steam plants, combustion, transmission lines, millwright work, complete mine installations, rock work, rock crushers and conveyors. Executive ability. Speaking French fluently. Location immaterial. Apply to Box No. 1482-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.Sc. '31 (Univ. of Alta.), Jr.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work. location immaterial and available at once. Apply to Box No. 1522-W.

CIVIL ENGINEER, B.Sc. '32, S.E.I.C., P.E.N.B., DY.L.S.N.B., age 32. Experience in mining, both coal and metals, private and legal surveys, railroad construction, geology and building construction. At present in private practice in coal mining district. Desirous of changing location for position either in mining field or construction in Canada. or abroad. Apply to Box No. 1562-W.

RESIDENT ENGINEER, familiar with all types of surveys and construction work including, railway, roads, irrigation, drainage, buildings and air ports. Executive ability. Had charge of several large projects. Intimate knowledge of reports and estimates. Available immediately. Any location. Apply to Box No. 1567-W.

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OCTOBER, 1937 VOLUME XX, No. 10

# Contents



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THE ENGINEERING JOURNAL

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# Recent Developments at the Port of Halifax

*E. H. James, M.E.I.C.,*
*Consulting Engineer, Montreal.*

**Paper presented at a joint meeting of The Institute and the American Society of Civil Engineers, Boston, October 6, 1937.**

SUMMARY.—The main Port facilities in Halifax Harbour are at two points some 1¼ miles apart. The construction of the various piers is described, with notes on the difficulties experienced, and the reconstruction or extensions carried out from time to time during the past twenty years.

The Port of Halifax is situated on the Atlantic coast of Nova Scotia about 7½ miles in from the open sea and is one of the two principal Eastern seaboard ports of Canada, the other one being Saint John, N.B.

Halifax has an exceptionally fine natural harbour with a useful water area of about 10 square miles. There is ample depth of water for all purposes, no dredging ever being required except for the shoreward parts of new construction, and there being no rivers of any size entering the harbour there is no trouble with any form of siltation. Foundation conditions are good; the tide range is only about 6.7 ft., while currents are negligible, never exceeding about one mile, and Halifax is still the only port in Canada which can dock any ship now afloat at any time of the year.

The business of the port is largely seasonal, being very much greater during the winter months than in the summer when the ports of Montreal and Quebec on the St. Lawrence river are operating. As a natural result of this situation much of the accommodation which is busy in the winter is often necessarily idle during the summer months.

The city of Halifax was originally founded in 1749 and in the early days most of the pier construction was carried out by the naval and military authorities. During the nineteenth century, however, extensive trading was carried out between Halifax and the West Indies and American ports and during this period a number of timber pile wharves were constructed by various private interests, mostly located in the section between the present Deep Water and Ocean Terminals, and most of these properties are still privately owned.

The first railway connection to Halifax was in 1858, this railway being taken over in 1876 by the Intercolonial Railway. From this time until 1928 the port, apart from privately owned docks, was under the control of the Government Railways. In 1928 the Halifax Harbour Commission was formed, consisting of three local Commissioners appointed by the Federal Government. This body remained the controlling authority until 1935 when in common with the other principal ports of Canada, viz., Montreal, Quebec, Vancouver, Three Rivers, Saint John and Chicoutimi, Halifax was taken over by a central body known as the National Harbours Board. This body consists of three Commissioners, with headquarters in Ottawa, who control all ports, appoint the local port managers and also carry out all new construction work, the work of the port chief engineers being now confined to maintenance work and minor new works.

Reference to the general plan shown in Fig. 2 will show that the main port facilities are divided into two sections, the inner portion known as Deep Water Terminals and the outer known as Ocean Terminals. The early development was at deep water in the neighbourhood of the naval dock yard, but in 1913 the facilities were becoming inadequate to handle the traffic and a very extensive new scheme of development was put in hand. This new development, instead of extending the existing facilities at Deep Water, was removed to an entirely new area some 1¼ miles nearer to the harbour entrance, and as no rail connection could be established along the water front between the two sites owing to lack of space and existing streets, the new scheme involved construction of a railroad around the back of the city and the removal of the railway terminals to the new site. At the time this work was put

(*Courtesy of R.C.A.F.*)

**Fig. 1—Aerial View of Halifax Harbour and Bedford Basin.**

in hand the Harbour Commission had not been formed, and the construction of the first units was carried out between 1913 and 1919 by the Government Railways.

There has been considerable difference of opinion regarding the wisdom of developing the new site, as this location is undoubtedly more exposed than the inner harbour and some berths are even now undesirable when the wind is in certain quarters. The new scheme involved also the construction of a protecting breakwater, the moving of the railway terminals, the construction of the new railway line, part of which was in heavy rock cut and requiring a number of over bridges and the building of a new passenger station and yards. From an operating point of view the port labours under the disadvantage of having two separate sections a considerable distance apart without direct rail connection, the time required for switching being very considerable. On the other hand the new location provided for almost unlimited expansion when needed and employed land which was cheap and not otherwise in use at the time, whereas the space available at Deep Water was limited towards the north and already occupied by numerous private interests and therefore involved expropriation towards the south.

It is not proposed to give any detailed description of facilities in existence up to this time as they have been dealt with exhaustively in other papers, though a general idea of the situation may be given here.

At Deep Water Terminals there is a pier known as Pier 2, about 780 ft. by 235 ft., built between 1912 and 1915. This pier was originally intended to be one of four to form part of an extensive new development, but no further units were ever proceeded with. The pier is supported on 24 in. square concrete piles with concrete deck and carries a two storey concrete shed about 200 ft. wide in five spans. Two railroad tracks run into the shed under cover on the lower floor and there is an outside track on each apron. This pier survived the disastrous explosion of 1917 and is still in good condition and handled a tremendous amount of business during the War. The concrete piles were recently inspected and were found to be all sound below water, but above low water, particularly in the case of those piles which were too short when driven and were extended *in situ*, considerable deterioration took place due to frost action, etc., and in 1929 and 1930 about $230,000 was spent repairing these upper portions and the under side of the deck system. All loose concrete was cut out and all exposed reinforcing sand blasted, after which the structure was re-surfaced with gunite impregnated with finely ground iron. This work is at the present time sound and the pier generally is in very good condition.

There are also two timber piers known as 3 and 4, about 160 ft. by 606 ft. and 82 ft. by 540 ft. with one storey timber sheds. These piers were built in 1898 and 1892 and are still in fair condition and in regular use, but they were practically rebuilt in 1917.

At Richmond, about 1¾ miles above Deep Water, there is an open wharf parallel to the shore line about 700 ft. long. This is an old timber structure and is not in very good condition though still serviceable. It is leased in sections to various industries requiring water front accommodation. There is also a large cattle shed and facilities for handling cattle by rail and water.

Richmond was the site of the earlier railroad developments and the accommodation was at one time much more extensive than at present. The greater part of the facilities, however, were destroyed in the 1917 explosion and were never rebuilt.

Accommodation at Ocean Terminals consists of a long wall 2,006 ft. in length, parallel to the shore line and providing 45 ft. depth at low water, capable of docking the largest ships afloat. (See Fig. 3.) There is a return wall

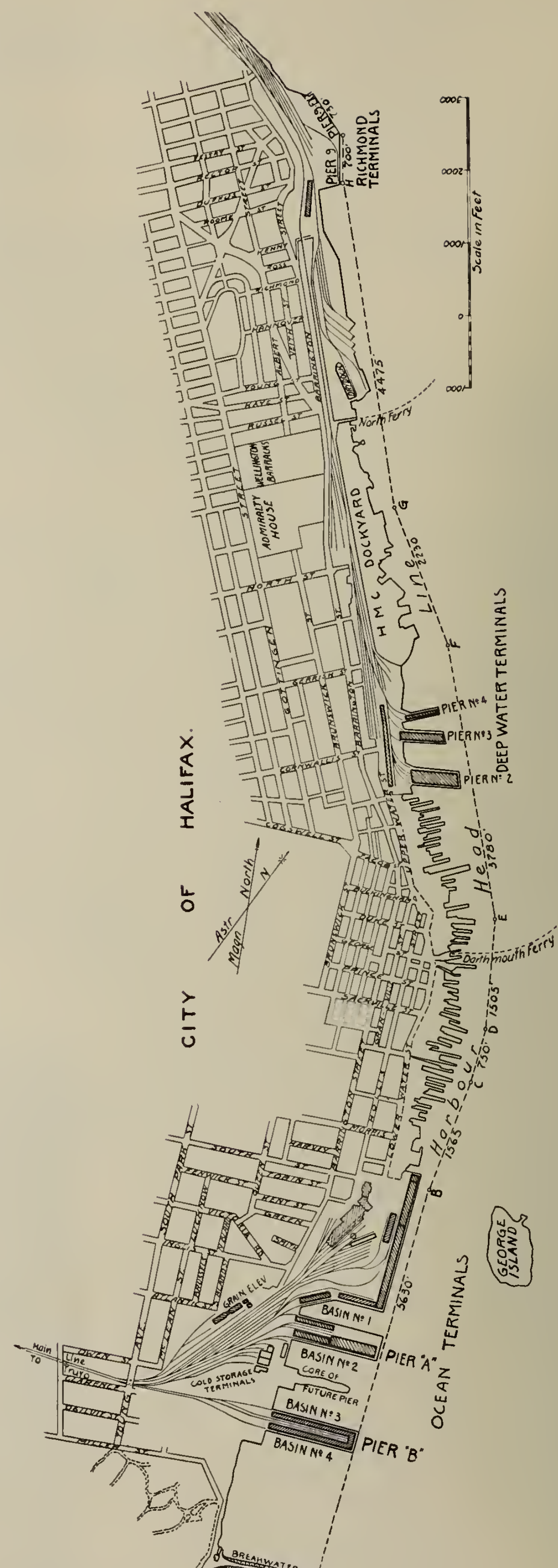


**Fig. 2—General Plan Showing Terminal Facilities.**

**OCEAN TERMINALS**

**EXISTING BERTHING ACCOMMODATIONS**

| LOCATION | BERTH Nº | BERTH LENGTH | DEPTH OF WATER AT L.W.O.S.T. | TRANSIT SHEDS | SHED CONSTRUCTION | REMARKS |
|---|---|---|---|---|---|---|
| Ocean Terminals | 20 | | | 596' × 95' 4" | Structural Steel | 596' One Storey |
| | 21 | 2007' | 45' 0" | 530' × 98' 0" | " " | 530' Two " |
| | 22 | | | 622' × 98' 0" | " " | 622' " " |
| | 23 | 720' | 35' 0" | 506' × 90' 0" | Timber Frame with | |
| | 24 | 440' | 30' 0" | 440' × 90' 0" | Perm. Found. & Floors | |
| | 25 | 625' | 45' 0" | 594' × 90' 0" | Timber Frame | |
| | 26 | 625' | 45' 0" | None | | Coal Handl. Plant |
| | 27 | 625' | 45' 0" | 655' × 90' 0" | Structural Steel | 655 × 42' Train Shed |
| | 28 | 625' | 45' 0" | 550' × 90' 0" | Timber Frame | |
| | 36 | 625' | 35' 0" | 600' × 94' 6" | St. Steel Frame | Office West End |
| | 37 | 625' | 45' 0" | 600' × 94' 6" | " " " | |
| | 38 | 300' | 45' 0" | 73' × 80' 0" | " " " | Connected E. End |
| | 39 | 625' | 45' 0" | 600' × 94' 6" | " " " | |
| | 40 | 625' | 35' 0" | 600' × 94' 6" | " " " | Office West End |
| | | | 22' 0" | 2- Berths - 200FT Long | | |

**DEEP WATER TERMINALS**

**EXISTING BERTHING ACCOMMODATIONS**

| LOCATION | BERTH | LENGTH | DEPTH OF WATER AT L.W.O.S.T. | TRANSIT SHEDS | SHED CONSTRUCTION | REMARKS |
|---|---|---|---|---|---|---|
| Pier Nº 2 | South Side | 660' | 33FT to 58FT | 680' × 200' | Reinf. Concrete | Two Storeys |
| " " | North " | 720' | 30' to 65' | 680' × 200' | " " | Top Storey Heated |
| Pier Nº 3 | South Side | 600 | 31' to 48' | 548' × 125' | Timber Frame | |
| " " | North " | 620' | 30' to 45' | 548' × 125' | " " | |
| Pier Nº 4 | South Side | 530' | 28' to 38 | 433' × 56 | " " | |
| " " | North " | 480' | 18' to 23' | 433' × 56' | " " | |

**RICHMOND TERMINALS**

**700FT QUAY WALL— LEASED TO INDUSTRIAL CONCERNS (IN PART)**

| LOT | LESSEE | FRONTAGE | DEPTH OF WATER AT L.W.O.S.T. | BUILDINGS | REMARKS |
|---|---|---|---|---|---|
| A | A.T. O'Leary | 117Ft | 28Ft | | Cool Handl. Plant |
| B | Vacant | 100Ft | 28Ft | | Open Storage |
| C | Can. Ind. Ltd. | 162Ft | 28Ft | Timber Frame Factory & Warehouse | Fertilizer Plant |
| D | Vacant | 100Ft | 28Ft | | Open Storage |
| E | Can. Cement Co. | 210Ft | 28Ft | Reinf. Concr. Silos & Packing Ho. | Cement Storage |
| Halifax Harbour Com's Cattle Transit Shed Timber Frame 500' × 79' - 50 Stalls | | | | | |
| Pier 9 Extension | | 730FT | 30FT | | |

Fig. 2A.

of about 1,200 ft. length at its southern end and also Pier A about 1,250 ft. by 300 ft.; altogether the development provided nine berths for large ships. The long wall is provided with two storey brick and steel transit sheds on two berths, Nos. 21 and 22, built between 1921 and 1926, and a single storey steel shed on one berth, No. 20, built in 1929, and accommodation is also provided for the port administrative offices and immigration quarters. The remaining berths have single storey timber sheds, four of which, Nos. 23, 24, 25 and 28, were built in 1917 to 1918, while one, No. 27, was built in 1929. Berth No. 26 is open, as it is occupied by the Dominion Coal Company's handling plant.

The substructure work in this section is of a very high grade type and all walls above low water are faced with granite blocks; the base of the wall consists of a number of reinforced concrete shells set one on top of the other to the required height, having the front pockets filled with concrete and the rear ones with rubble rock. The base course was set on carefully prepared foundations, this work being carried out in the dry inside a large diving bell. Towards the shore the work involved a large amount of rock excavation while for part of the outer sections a rubble mound was required to provide the foundation for the shells, as bed rock was lower than −45. At the southern end of the entire development a protecting breakwater was built from the largest pieces of rock excavated from the cut for the new railway approach, and as there was still a large surplus of rock this was dumped on what was intended to be the site of the next unit to be built under the scheme, to form its central core.

There is also a 2,200,000 bushel grain elevator with galleries making most berths available for grain shipments and a cold storage plant, this latter having originally been built as a private enterprise although it was taken over by the port.

This was the position of the port when the Harbour Commission was formed in 1928, no works of any size having then been carried out for some time. In this year it was decided to build an additional unit in the original Ocean Terminals scheme. In the ordinary course of events the existing core mentioned before would have been used as part of this new pier, but the location of the cold storage plant erected in the interval had made it practically impossible to provide suitable trackage to a pier on this site and the new Pier "B" was therefore built on the next site seawards, still however adhering to the original general plan.

### Construction of Pier B and Transit Sheds at Ocean Terminals

This pier is 1,250 ft. by 300 ft. and the type of construction adopted consisted generally of large concrete cribs filled with pumped sand with concrete superstructure

(*Courtesy of R.C.A.F.*)

Fig. 3—R.M.S. *Majestic* at Passenger Landing, Ocean Terminals.

wall and a central rock and sand fill. As additional yard space was needed by the railway a further large excavation was made immediately behind the pier and the spoil used as filling, the amount required over and above this being obtained near the harbour entrance by a sand sucker and pumped into the pier site.

A considerable amount of rock dredging was required at the shore end of the pier where the basins were dredged to 35 ft. at low water while at the outer end a rubble mound was dumped up to 45 ft. below low water, and the cribs set on this mound, after depositing a bed of crushed stone and carefully levelling it off by sweeping with a heavy beam suspended beneath a scow. There were therefore two types of cribs, those for the 35 ft. depth being 42 ft. wide and those for 45 ft. depth 52 ft. wide. All cribs were built of a height sufficient to bring them above high water when set. The cribs were constructed in a floating pontoon on the Tromenhauser system in which the crib floor is poured on the bottom of an open pontoon and the construction of the walls started with forms erected inside the pontoon. As work proceeds the increasing weight forces the pontoon lower into the water, but before it is submerged the crib is able to float itself and the pontoon is then removed and the bottom forced off by weighting its projecting edges, after which the crib is completed afloat, the pontoon being reassembled for the next crib. This method of construction has many advantages and can be used in almost any location but has the disadvantage common to most floating methods of starting concrete cribs, that it is almost impossible to make the pontoons so rigid that they will not distort somewhat during the pouring of the floor slab. As a result of this the crib floor is often not a plane and when the crib is set and filled very large and indeterminate stresses may be set up owing to its not bearing evenly in its bed. Moving forms of the grain elevator type were used for the walls of the cribs, lifted continuously by jacks. When the cribs were completed they were towed to the site and sunk in position by admitting water by siphons and were then filled with pumped sand. Aluminous cement was used throughout for the crib construction with a view to avoiding deterioration through sea water and frost action, and owing to the great heat developed by this cement when the concrete is setting it was necessary to install pipes on the lower edges of the moving forms to cool the concrete. The spaces between cribs were filled in with bag concrete to the underside of the superstructure wall, the bags being set in place by divers.

It was originally intended that the outer wall of the cribs should form the actual dock face, to a level just above high water, but in practice many of the cribs were not set to a perfect line and a number moved after setting as a result of settlement in the rock mound when the cribs were loaded. This situation was remedied by slightly increasing the width of the pier and bolting a timber waling to the cribs just above low water, shaped so that its outer edge was exactly to the new line. The superstructure wall on the cribs was then carried down to the timber waling, thus providing a finished wall to a perfect line, the irregularity of the cribs themselves not being visible. This wall was reinforced and was held to the crib walls by bolts passing through them and supporting a reinforcement system. The superstructure wall was partly built with aluminous cement and partly with Portland cement, and time should therefore show definitely whether aluminous cement is or is not superior to Portland cement for resisting frost and salt water action. The cement used was a European one known as Ciment Fondu which was developed in France and is now manufactured in England. Its price was however about twice that of Portland cement, so that its advantages need to be very considerable to make its use for this type of work economical.

After construction was started a change was made in the width of the pier, which was increased from 260 ft. to 300 ft. so as to provide additional trackage and permit of double banking cars at the back of the sheds, a proceeding usually adopted when shipping apples, the cars on the outer track being unloaded through those on the inner track. When the substructure was completed in 1932 money was not immediately available for sheds and the pier was used only for open storage until 1934 when arrangements were made for the construction of the sheds shown in Fig. 4.

The new shed was a one-storey steel structure about 94 ft. 6 in. wide, built continuously along both sides of the pier, and across the sea end, so that it is possible to travel completely round the pier inside the shed, thus providing four berths 600 ft. long and one 300 ft. long. There is a single railroad track on each apron at the water side of the sheds and four in the centre, two behind each wing of the steel shed with a truck roadway in the centre providing access to the outer part of the sheds without passing through the inner parts.

The first problem to be dealt with was the question of foundations for the sheds, no provision having been made therefor in the design of the substructure. As explained before, the central fill consisted of well consolidated rock up to a certain height which varied considerably but was generally below low water, and above this fine sand which had been placed hydraulically. This fill had been in place for some time and was well consolidated but it was evident that a considerable amount of leakage of the fine sand was taking place, partly through the bagwork in the spaces between the cribs and partly as a result of the very fine material gradually drifting into the interstices in the rock fill beneath, and it was decided for all rear columns to use piled footings taken through the sand down to the rock fill. For the front columns which were over the sand-filled cribs near the front it was not thought there could be any settlement and spread footings on the sand were provided. When the ground was opened up however a test load was put on the sand over the cribs and it was found that considerable settlement took place. Investigation showed the following reason:—

The sand filling in the concrete cribs was extremely fine and as the cribs were practically watertight the water

Fig. 4—General View of Sheds, Pier B.

pumped in with the sand was still present so that the contents of the cribs was practically a quicksand. Piles were driven into the cribs as an experiment and these went down about 4 or 5 ft. a blow until they met the crib bottom and if the hammer was then lifted the pile would come up about 3 or 4 ft., but if the hammer was left on the pile for about 10 to 15 minutes the pile would remain in position after lifting the hammer. After considering various alternatives and estimating their cost, it was eventually decided in the case of the large cribs to bridge the crib pockets from wall to wall by a continuous reinforced concrete beam and carry the footings for the steel columns on these beams and to use pile foundations driven to the bottom of the cribs in the case of the smaller cribs. This situation involved a large amount of excavation and additional concrete work and piling and increased the cost of the shed construction by a considerable amount and indicates the advisability of always providing for the foundations of future sheds when the substructure is built. There has however been no trouble with these foundations since the work was completed.

It is desirable for handling freight from ship to shed that the dock apron should be level with the shed floor on the water side but at the rear of the shed where the traffic is between shed and cars, the shed floor must be about car floor level, involving the necessity for depressed tracks. As the approach to the pier was already on a considerable grade, the shed floors were sloped upward from front to back so as to increase this grade as little as possible, thereby reducing the track depression by about 1 ft. 9 in. This grade on the floor has not been found any disadvantage, particularly as the outgoing traffic is greater than the incoming and towmotors are largely used. The retaining wall at the rear of the sheds has no foundation being a concrete curtain supported by the footings for the columns and only carried about 12 in. below ground level.

The shed floor is a 6 in. concrete slab reinforced with wire mesh and panelled to provide for expansion and contraction and is laid directly on the sand fill.

The steel shed structure is a single span, avoiding all obstruction on the floor by columns, and consists of steel trusses carried on built up steel columns with channel purlins to support the roof deck. The structure is closed in with galvanized corrugated steel siding, with a considerable window area supplied with ventilated steel sash.

Most of the older sheds at Halifax are provided with continuous sliding doors, permitting of any bay being opened. However Halifax is mainly a winter port and operation therefore has to be carried out under snow and ice conditions; further, its climate is such that thaws frequently occur when the sun is out in the day time followed by freezing temperatures at night, and sliding doors had proved very troublesome under these conditions owing to snow and ice collecting in the lower guides. It was therefore decided to use folding vertical lift type doors for the new shed. As the cost of these doors per opening greatly exceeds the sliding type, doors at the front of the sheds are only provided in each alternate bay. These doors are 14 ft. high and 18 ft. wide and are of two different types. On the north side they are 3-leaf doors and on the south 2-leaf doors. At the back of the shed doors are provided in every bay and are all of the single leaf vertical lift type by the Truscon Steel Company. These doors are 9 ft. high and 18 ft. wide, except for one opening in each shed section which is provided with a 14 ft. door similar to those on the water front side to provide for movement of any exceptionally large piece of freight. They are very rarely needed however.

All these doors have proved satisfactory after the adjustment of a few initial difficulties. All doors are operated by hand chain gear and those at the back of the sheds operated so easily that they could be closed by pulling the door down without using the chains. This caused the chains to travel so fast that they flew off the sprockets and jammed so that special guides had to be provided to prevent this trouble.

All doors are very carefully weatherstripped to prevent the ingress of driving snow and rain and have proved to be satisfactorily weathertight.

It was originally intended to use a mill type roof built up of 2 in. by 4 in. timber, but owing to the very high winds experienced at times at Halifax, trouble had been experienced as a result of air passing through the timber deck and tending to blow off the roofing; it was therefore decided to use a 1½ in. T. and G. deck, carried on 3 in. by 5 in. rafters. Nailing strips were omitted on the purlins and the rafters were attached directly to the steel by means of 1 in. by 1/8 in. cadmium-plated strips which passed round the purlins and were spiked to the sides of the rafters so that the nails are in shear. This method of fastening has proved perfectly satisfactory and the whole roof deck was actually considerably cheaper than the original mill type design. The roofing is a 5-ply felt, tar and gravel bonded roof and special care was taken with the nailing and mopping to avoid any tendency to lift. The eaves troughs are of timber on steel supports and are lined with copper. Eighteen copper ventilators are provided in the roof.

Each of the two long wings of the shed is divided at the mid point by a solid brick firewall carried 3 ft. above the roof, the external portion being completely sheathed in copper flashed down to the roofing. Connection between the sections through the walls is provided by sliding automatic fire doors.

At the shore end of each wing a brick office block is provided, each having two floors, the upper floors containing office space subdivided as required by tenants, while the lower floors contain heated rooms for perishable commodities or stores. The main entrances to the sheds pass through archways on the lower floor and under the office space. A heating plant is provided supplying both office blocks and there is also a transformer and switchboard room for the lighting installation.

The main sheds are lighted with Holophane reflectors which provide a diffused light without dark shadows, and the exterior is also similarly lighted from brackets on the roof, both on the water side and at the rear of the sheds; power connections for portable electric equipment are installed at intervals.

Water supply is provided with connections to fire hoses inside the sheds and to three hydrants located outside. Along the dock face connections are provided to boxes below floor level for supplying water to ships, portable meters being used to measure the quantity delivered.

Open type gear rooms are provided in each section built of heavy galvanized wire mesh on tubular supports, these being carried up to the underside of the roof trusses. With this type of room all gear can be seen but is protected from theft and is also well ventilated.

The concrete floors were finished with a wood float to provide a rough surface, as during the winter there is a lot of condensation on the floors and smooth or asphalt finish floors become extremely slippery.

There is a sewerage system running the entire length of the pier with an outfall at the outer end which picks up all down spouts from the roof, catchbasins on the roadway and sewage from the office buildings.

A complete sprinkler installation is provided, which since the shed interiors are often below freezing is of the dry pipe type. It is controlled by heat actuated devices which admit water to the system when the temperature rises at a greater rate than a certain pre-arranged speed. If these devices go into action an alarm is sounded but no water can escape unless a head goes, and after water is admitted the system practically becomes a wet pipe system.

This system avoids the necessity for a considerable air pressure in the pipes and avoids the release of water as a result of accidental breakage and consequent damage to cargo; it further gives an alarm some time before a head would go and therefore a small fire might be extinguished by hand equipment before a head went, thus avoiding water damage.

The water supply to the sprinkler system is derived from the city mains and also from an automatic fire pump with suction direct from the sea, which goes into action if the pressure drops below a pre-arranged figure. Thus the pump not only supplies the required water in the event of a failure of the city mains but also boosts the pressure if this should become too low.

The shed work included paving the approach roads and providing an independent stevedores rest room, provided with lavatory accommodation. The tracks were laid by the Canadian National Railways, but the paving of the aprons around them was part of the shed contract.

The cost of the entire work was approximately $965,000, and as no money was available at the time the sheds were required, the contractors financed the entire project, receiving payment after completion and acceptance of the whole work in 3 per cent bonds of the Commission redeemable at par 3 years after acceptance of the work. As a result of this arrangement the contractor had to bear all financing charges with the result that the cost was of course greater than if open competitive bids had been called. The general contractors were the Dominion Bridge Company and the J. W. Cumming Manufacturing Company jointly, and the work was entirely completed during the 1934 summer season.

### Reconstruction of Pier No. 2 at Deep Water Terminals

In September 1933 a disastrous fire started on the upper floor of Pier 2 at Deep Water. Some 7,000 tons of cargo, principally flour, were destroyed and the upper storey of the concrete shed was completely wrecked. As the winter season was due to start in three months and this shed was urgently needed, much of its space being already booked, it was necessary to rebuild at the earliest possible moment.

It was almost a week after the fire before the upper floor was cool enough for the damage to be inspected. The

Fig. 5—Clearing Up After Fire, Pier 2.

shed was entirely of reinforced concrete and the upper storey had completely collapsed leaving only a tangled mass of broken and disintegrated concrete and reinforcing steel. The only portion of the upper storey which was still standing was a few bays at the shore end, the only part which the fire department had been able to reach.

A contract was immediately placed on a force account basis for the removal of all wreckage amounting to some 7,000 tons (see Fig. 5). This work took three weeks and at the earliest possible moment an inspection was made of the floor slab to ascertain if it was still serviceable. For this purpose numerous test sections were cut out of the slab and crushed and it was found that the strength was generally not seriously reduced, though a few bays had to be removed and replaced owing to partial disintegration of the concrete. The original floor was a 6 in. concrete slab with a 1½ in. finish placed shortly after pouring. This had

Fig. 6—Reconstruction, Pier 2.

almost entirely separated from the slab proper and had to be completely removed, but there is no doubt that it had protected the main slab and prevented any serious damage.

In view of the time element and the early approach of freezing weather it was not considered practicable to rebuild in concrete and it was therefore decided to adopt a structural steel design. It was found impossible to drill holes for anchor bolts for the steel columns, owing to the mass of reinforcing steel in the floor system at these points, and therefore the old dowels for the upper floor concrete columns were left in place, bent over and concrete pedestals 18 in. high poured around them, the anchor bolts being set in these pedestals, which also provided protection for the light steel columns from damage by truck traffic on the floor. The steel framing was designed and a contract placed immediately, and as soon as the floor had been cleared its entire surface was covered with a 2 in. asphalt paving. For laying this floor a 10 ton roller was taken up and as this of necessity passed over every portion of the slab many times and its load concentrations were rather greater than those for which the slab had been originally designed, it provided incidentally a very good test for the slab. Concrete curbs were built round all floor openings for stairs, escalators, etc., and these temporarily covered with waterproof material so that the lower floor could be used as a transit shed while the work above proceeded. As this floor was quite flat the drainage was not very good and a certain amount of leakage took place on very wet days, but it was not sufficient to prevent the lower floor being kept in use, tarpaulins being kept handy to protect cargo when necessary.

The expansion during the fire was sufficient to cause severe cracking of the two concrete ends of the building and such cracks were all cut out and filled with gunite, while at the same time other needed repairs were carried out, the necessity for which had not been caused by the fire.

As the new steel structure (shown in Fig. 6) was in five spans the same as the original concrete sheds and the members were therefore all quite light, erection was carried out very rapidly by a small travelling derrick and presented no difficulty.

The roof deck was of timber 2 in. by 4 in. mill type laid on nailing strips bolted to the purlins and a new brick firewall was built at the mid point projecting through the roof.

A large part of this upper storey was often used for potato storage, for which purpose the shed had been insulated with a timber and fibre board lining backed by eel grass matting and heated. This lining was a fire hazard and had undoubtedly been responsible for the rapid spread of the fire and it was not considered desirable to repeat it. The main shed siding was corrugated galvanized iron throughout except for the shore end wall which was rebuilt in brick, and for the heated portion a 6 in. wall of hollow tile was built inside the sheeting between the steel columns leaving an air space, and the roof was covered with 1 in. of Donnacona board in two ½ in. layers over the timber deck and beneath the roofing. Insulated doors were also fitted to all wall openings and tile housings were built over the escalator and stair openings. This was not of course a very efficient method of insulation, but it was fireproof and was rapidly carried out at small cost and as it is only necessary to keep the temperature just above freezing it has proved quite satisfactory. Heating was accomplished by seven Dunham units fitted with automatic control, the temperature being maintained at about 35 deg. F. Roofing throughout was 5-ply tar and gravel. The outer half of the shed was not insulated in any way and was closed in by the siding only.

Ample large windows were provided in steel sash with ventilating sections, the windows in the insulated section being double and of smaller size. There are only eight outside doors in the upper floor opening on to projecting steel platforms and these were replaced in steel and wood in the unheated section and with refrigerator type doors in the insulated portion.

The paving contractor who laid the asphalt floor having no means of lifting his 10 ton roller on to the upper floor built a temporary ramp for this purpose and all asphalt from his plant was also trucked up this ramp. Another contractor took this over afterwards for his work and the arrangement was found so convenient that the Commission decided to make it a permanent feature. A new ramp was therefore built providing access for trucks to the upper floor. This ramp entered the shed at the side, and the opening was fitted with a refrigerator type door as it is in the insulated section. The arrangement has proved to be very useful and has saved its cost several times over in reduction of handling charges.

A sprinkler system of the same type as at Pier B was installed on the new upper floor. The question of installing a similar system on the lower floor was carefully considered but was decided against, as the design of the existing concrete structure is such as to make such an installation difficult and expensive.

The lower floor was originally equipped with continuous sliding type doors. These doors were old and already in need of extensive repair and were further considerably damaged as a result of the fire. Their operation had always been difficult in freezing weather and it was therefore decided to replace them.

A new installation of sliding doors would have involved new overhead track and new bottom guides, as these were badly corroded and in poor condition. In view of their difficult operation it was decided to replace these with 3-leaf vertical lift doors in each alternate opening, the blank openings being filled in with 8 in. interlocking tile panels, cement plastered outside, and containing a large steel sash. As the existing door openings were not rectangular, they were squared up by structural steel frames placed inside them which carried the new doors. Fitting these frames was a rather tedious operation as no two openings were of exactly the same dimensions and a lot of special fitting was necessary. The doors, however, since completion have operated very satisfactorily and the alternate opening arrangement has not caused any trouble with traffic handling.

The shed was fitted with four electric escalators and a freight elevator, all of which were considerably damaged, especially at their upper ends. A new elevator with push button control was installed and the escalators were taken out and shipped to their manufacturers who carried out the necessary repairs and replacements and re-erected them. It was also decided to install two additional escalators.

The concrete enclosures for stairways, etc., were badly cracked and otherwise damaged and where necessary these were taken down and replaced with 3 in. gunite partitions.

The shore and sea end walls of the shed which were of an ornamental character in reinforced concrete were seriously cracked and damaged as also were the offices contained in the first two bays of the shed. The upper part of the shore end wall was demolished and rebuilt in brick while the lower portion was repaired with gunite, all cracks being deeply cut out and refilled and all broken and detached portions of concrete built up again. New steel sash were required for many openings and sills and jambs needed reconstruction in gunite. New offices were built with tile partitions on the upper floor and the original lower floor ones were renovated, refloored and painted. The sea end wall was also repaired with gunite and was not replaced on the upper floor, the galvanized siding being carried round the end.

When all work was completed the entire shed presented a satisfactory appearance, the siding on the upper floor doors, etc., being painted harbour grey which harmonized with the concrete lower floor.

The whole work was completed by January 1934, but actually the lower floor went into use in December and the upper was largely used before actual entire completion, so that no serious delay was caused to traffic operations.

Throughout the design and construction close co-operation was maintained between the engineering and operating departments.

Owing to the urgency of this work time could not be taken to fully design the whole work and prepare plans on which tenders could be called for the whole work and therefore the engineers practically acted as general contractors, sub-letting the work in sections as the plans were prepared and carrying out some portions of the work with the Commissioners own forces.

### Construction of Fish Pier at Ocean Terminals

In 1934 it was decided to construct a small pier in front of the existing cold storage plant to provide accommodation for trawlers and fishing schooners that wish to land their catches for treatment in the plant; it was also proposed to provide space on this structure for the erection of fish processing plants. The pier was 290 ft. wide and 200 ft. long and use was made of the old rock fill in front of the cold storage plant which has been previously mentioned.

The large pier which was contemplated when this fill was originally placed was wider than the proposed fish pier and was also intended to provide a depth of water not less than 35 ft. at low tide, but for the purpose of the fishing vessels a depth of only 20 to 25 ft. of water was needed and it was therefore decided to use small concrete cribs about 70 ft. by 30 ft. and to set them on benches in the sides of the old rock fill, excavated in such a location that the required depth of water would be provided. The cribs carried a mass concrete superstructure wall and the centre was filled in with material obtained from steam shovel excavation and hydraulic dredging. The sea end of the structure was left open in view of the possibility of extension at some later date and the opening between the new wall and the central rock core was closed by small timber cribs to retain the earth portion of the fill. As the pumped material used for part of this fill was a very fine sand which erodes very rapidly, due to wind action in the summer when it is dry, it was specified that the upper two feet of the fill should be of some suitable heavy or compact material.

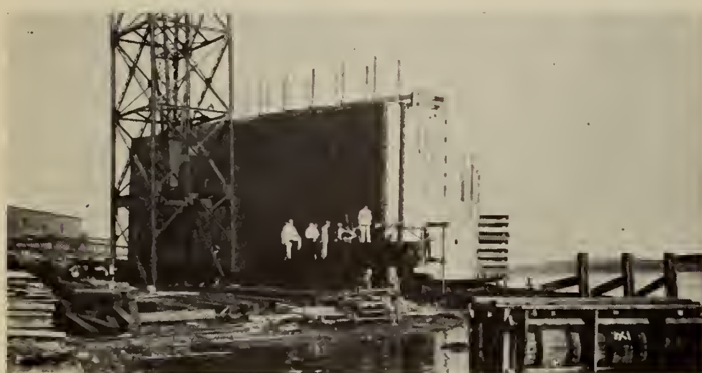

**Fig. 7—Launching Crib for Pier 9 (Richmond)**

**Fig. 8—Crib Launched, Pier 9 (Richmond).**

The formation of the benches on the side of the rock fill was carried out by a large drag line which travelled on the central core out of the water and had sufficient reach to cover practically the whole area. At the shore end of the basins a certain amount of rock excavation was necessary but as this only amounted to 2,215 cu. yd. it was carried out by a small two unit floating gasoline drill plant and the material after shooting was removed partly by the drag line and partly by a floating derrick and clam shell.

The concrete cribs were constructed on ways, as in the immediate neighbourhood a convenient piece of foreshore existed which was solid and almost at the grade required for launching. Panel forms were used for the concrete work and the pouring was carried out with the cribs in a sloping position at right angles to the ways, but as a very dry mix was used and the concrete vibrated no particular difficulty was encountered as a result of the slope.

Concrete was poured in these forms for a height of about 14 ft. after which they were removed, the cribs launched and completed to their full height while afloat. In all nine cribs were built and no difficulty was experienced either in launching or completing them afloat.

When the excavation was completed the bed for the cribs was levelled up by depositing approximately 12 in. of crushed stone and the cribs then sunk in their correct location by admitting water by means of portable gasoline driven pumps, pumping to a pipe header with valves on outlets to the different crib pockets. The spaces between the cribs were filled with bag concrete placed by divers, and brought up to the level of the under side of the superstructure wall. The cribs were filled partly with material obtained from shore and partly by gravel dredged by a clam shell near the entrance to the harbour. As these cribs were set upon an old rock fill which had had many years to consolidate, practically no settlement occurred when the cribs were loaded and they were therefore set very accurately. After the setting and filling of the cribs the superstructure wall was poured in place, the line being corrected by a slight overhang of the wall. Expansion joints were provided at 50 ft. intervals. The lower portion of the fill, in the V-shaped space between the back of the cribs and the old bank, was filled in with the loose rock previously excavated, after which the other material was placed. One crib was provided with a special valve chamber for the main water intake of the cold storage plant and provision also had to be made for extending a sewer and a small open stream which was collected by a culvert and carried beneath the filling to the outer end of the pier. The new work was connected up to the existing bulkhead cribs of Piers A and B, so that the superstructure wall is now continuous. The pier is now in use for the accommodation of fishing vessels, but up to the time of writing the work of constructing the proposed fish processing plants has not been proceeded with.

### Extension of Wharf at Richmond. (Pier 9)

At the same time as the above work was authorized it was also decided to extend the wharf at Richmond owing to the desire of the Commissioners to remove the plant of the Dominion Coal Company from Pier A to a new location. This coal plant is in the middle of the passenger terminals and when operating in a high wind is objectionable owing to the blowing of coal dust. In addition to this there were requests from certain industries to lease property with water front facilities who could not be accommodated unless further space was provided. The new work at Richmond, about 730 ft. long, connects with the existing wharf parallel to the shore but makes an angle therewith of about 150 degrees. As the old work was a timber crib structure it was decided to use timber crib work for the extension. The new cribs were approximately 100 ft. by 35 ft. and stepped at the back. They were built partly of 10 in. by 10 in. local hemlock and partly, for the longer timbers required, of 10 in. by 10 in. B.C. fir. The face timbers of the cribs were creosoted and protected by sheeting with 3 in. creosoted hard wood, as there is a certain amount of activity by limnoria in Halifax Harbour. (See Fig. 7.)

For the construction of the cribs the contractors decided to use one of the disused ways of the Halifax shipyards which was quite close to the site of the work. This involved launching the cribs in a longitudinal direction instead of the more usual broadside method. Further, instead of launching after a few courses had been completed and finishing the cribs afloat, they were entirely finished and partly ballasted on the ways.

The contractor made a number of experiments with a model before the first launch and the experiments worked out quite satisfactorily. When the first crib was launched, however, shortly after its mid point had passed the end of the ways the leading end plunged downwards suddenly, lifting the rear and throwing the greater part of the weight on to the supporting timbers near the end of the ways. These timbers failed under the increased load and the crib fouled the ways with about two-thirds of its length over the end and considerable difficulty was experienced in extricating it from this position. It was eventually necessary to excavate considerable material in the front of the ways and put new timbers beneath the crib when with the combined efforts of floating derricks and jacks at the rear, the crib was eventually successfully launched. Inspection showed that with the exception of the above mentioned broken timbers which were replaced, the crib had not suffered any serious damage and it was eventually set in place quite satisfactorily.

Trouble was also experienced with the second crib launched, although the difficulties in this case were not nearly so severe. It was finally decided to sheet the leading pockets with 1 in. timber to provide flotation for the front end of the crib when launching. This arrangement solved the difficulty and no further trouble was experienced. (See Fig. 8.) The light sheeting usually failed soon after the crib was clear of the ways and it then floated on an even keel. Owing to the two steps at the back of the cribs certain pockets had to be ballasted before launching so that the cribs would float level and to avoid any tendency to turn over. The weight of filling required for this ballasting was determined by experiments with the model and the results obtained turned out to be quite satisfactory.

While the cribs were being constructed the necessary dredging of the site to provide a bed on which to set the cribs was carried out. The soft material overlying the rock was removed by clam shell dredges and, when suitable, was deposited behind the line of the crib wall to form part of the fill. Rock excavation was carried out in the usual manner by means of drill boats and the broken rock afterwards removed by the dredges. In those portions of the site where the rock was below the level of the crib seats the ground was built up to the required height by a rubble mound formed from rock taken from dredging and from imported material. After the excavation and mound had been completed the beds were levelled up with about 12 in. of crushed stone and the cribs sunk in place.

Before bringing the cribs to the site it was necessary to add a considerable amount of ballast so that they would be floating sufficiently deeply in the water to enable them to be grounded in a comparatively short space of time. This operation, owing to the shape of the cribs, had to be carried out with considerable care, as at times the addition of a very small amount of weight on one side or the other would cause the cribs to tilt over suddenly to an angle of almost 45 degrees. The cribs were usually brought to their desired locations around high water and were provided with guides which held one end in its correct position relative to the last one set, while the free end was manoeuvred into place by means of lines handled from a spud derrick. The cribs were allowed to ground on the falling tide and additional ballast rapidly added to prevent their flotation on the following rising tide, after which they were entirely filled with stone and preparations made for the building of the concrete superstructure wall.

As these cribs could not be set to an absolutely exact line and several of them settled and moved somewhat after loading, the face was brought to the correct cope line by attaching a creosoted timber waling to the cribs, built continuously throughout the whole length of the wall and so shaped that its outer edge was on the correct line. The superstructure wall was poured from a temporary gantry constructed on top of the cribs, and was provided with construction joints at 50 ft. intervals. The lower portion between low and high water was sheathed with creosoted timber which acted as a form and remained permanently in place to protect that portion of the concrete wall within the tide range from deterioration due to frost action. The northernmost end of the crib wall was connected to shore by dumping a bank and the impounded area filled in with material partly obtained by hydraulic dredging and partly from shovel pits close to the site of the work.

It was necessary to provide for the extension of several sewers and surface water drains which had previously discharged along the shore. These were collected in culverts and carried to the face of the new wall.

### Reconstruction of Grain Galleries at Ocean Terminals

While these two larger projects were proceeding a number of smaller works were carried out, the principal of which was the reconstruction of certain grain galleries. The existing galleries carrying grain from the elevator to the various berths were constructed many years ago in timber and a large number of the posts had rotted at their lower ends and in other locations where water was able to collect. In addition, these high timber galleries, the legs of which passed through the timber transit sheds, presented a very considerable hazard should fire break out in any of the sheds. It was therefore decided, instead of undertaking repairs to the existing timber structures, to make a start on the eventual replacement of the whole gallery system in steel. The section put in hand at this time involved the reconstruction of the important tower "B," any accident to which would put practically the whole grain conveyor system out of action, and the galleries on berth No. 25.

In 1931 a steel marine leg for unloading grain from ships had been built on this berth and in the reconstruction of the galleries a double deck system was installed to provide more convenient working from this tower, provision being also made for future extension of the gallery along berth No. 26 which is at present occupied by the Dominion Coal Company, the intention being at some future date to remove the coal plant to another location and to construct a transit shed on this berth. The grain gallery work was carried out by the John S. Metcalf Company, of Montreal, and was completed with almost no interruption to grain traffic. All those portions of the steel work which passed through existing transit sheds were fireproofed with a coating of gunite to a height of some 20 ft. above the sheds to protect them in the event of any conflagration in the sheds. The timber loading platform in front of the transit shed, which was in bad condition, was removed and replaced in concrete, all concrete foundations being brought

Fig. 9—Building Cribs, Imperial Oil Company Pier.

up to the level of the platform and a new concrete apron was also laid at this berth and on berth No. 23 on the opposite side of the basin.

### Construction of Pier for Oil Shipment at Imperoyal

The Imperial Oil Company have a large refinery on the opposite side of the harbour to the city of Halifax where they have their own town known as "Imperoyal." All waterborne shipments of crude or refined products were shipped from a timber dock at this refinery which in 1934 was in poor condition, and about this time the Company decided to build a new pier. Construction on this work was started in the spring of 1935 and completed about January 1936. As shipments are handled from boat to shore or vice-versa by pumping, the main purpose of the pier was to carry the necessary pipe lines to a point at which the ships can lie with sufficient depth of water. As the vessels engaged in this business include the very large tanker, *C. O. Stillman*, the minimum depth of water

**Fig. 10—Launching Crib, Imperial Oil Company Pier.**

had to be not less than 35 ft. at low tide. The pier consisted of four concrete cribs 98 ft. long by 44 ft. wide, set about 2 ft. apart, with 18 in. exterior and 12 in. interior walls dividing the crib into 24 cells. These cribs were built on the Halifax side of the harbour at approximately the same location as those for the Fish Pier referred to before, where the foreshore is at a convenient slope for the construction of ways.

As the contractor for this work proposed to use the sliding type of forms for the crib construction and it was therefore not thought desirable to build these cribs on a slope, the ways were provided with a rocking device which enabled the bottom slab and first 14 ft. of the crib walls to be poured in a horizontal position. (See Fig. 9.) When the pouring had reached this point and the crib was ready to launch it was tilted on the rocking ways until the tilting platform was in the same line as the ways, this being accomplished by nine jack screws attached to a frame behind the platform. The process of tilting occupied from 2 to 3 hours after which the links which prevented the crib from sliding before the tilting was completed were released and the crib allowed to slide down the ways into the water. The tilting platform was built up of nine heavy timbers, one below each cross wall of the crib, and under about the centre of each timber there was a heavy steel box girder which ran on a curved steel plate set in concrete, so that the crib and its platform could roll from the horizontal to the inclined position. When the lower part of the crib was being poured the platform was blocked up solid, and was set slightly off centre on the curved plates to avoid any tendency to run away when the blocking was removed.

While the crib was being tilted it practically formed two cantilevers as it was only supported at the centre point, and to resist the heavy stresses set up at this time some additional steel was added to all cross walls near the top of the 14 ft. height poured before tilting.

It was usually necessary to start the crib moving by means of hydraulic jacks, but very little pressure was required for this purpose. All four cribs were successfully launched without any difficulty, as shown in Fig. 10, the forms being left on during the launch and the pouring subsequently completed afloat alongside the bulkhead of Pier "B" where there was the necessary depth of water at low tide. As the height of the cribs increased it was necessary to ballast them by admitting water to prevent them becoming unstable.

While the construction of the cribs was in progress the necessary dredging was carried out at the site of the pier. The bottom at this point was on a moderate downward slope seaward and to avoid extensive dredging a location was selected where the necessary 35 ft. of water could be provided by dredging a bench on the floor of the harbour, low portions of the foundation being raised by depositing rubble rock to bring the bed up to the correct elevation. When this work was completed 12 in. of crushed stone was laid over the foundation and carefully levelled off by means of sounding and sweeping.

The approach to the pier is by means of a creosoted pile trestle from the shore which carries the 14 pipe lines required for handling the oil. This trestle was also constructed while the concrete cribs were being built to provide access to the work and when everything was ready the first crib was set at the end of this trestle. The trestle itself provided means of holding one end of the crib in its correct position, while the other end was controlled by means of a large salvage derrick boat having the necessary winches and gear for handling a number of lines. When the crib was in the correct position it was sunk by admitting water through valves until it grounded, after which the position was checked and if correct the crib was allowed to fill to prevent flotation on the rising tide. After the first crib was set the second and subsequent cribs were placed in position in the same way, the previous crib providing the means of holding one end while the derrick boat, as before, controlled the other.

Owing to some difficulties in carrying out the dredging work the cribs were completed some time before it was possible to set them and owing to the risk of having these cribs afloat for long periods and the lack of availability of suitable berths for storing them the contractor decided to beach one of the cribs on a convenient piece of foreshore and to lift it again when required by pumping out water. The crib was successfully beached, but unfortunately some days after it slid down the foreshore into deep water,

**Fig. 11—Filling Cribs, Imperial Oil Company Pier.**

taking up a position such that at low water one corner of the crib only was visible, the remainder being totally submerged.

The cribs had been insured by the contractor and the insurance company decided to attempt the salvage of the crib, consequently a contract was placed with a salvage company to carry out the work. A cofferdam was built around the crib, the timber sheeting and strutting being placed by divers. When the cofferdam was completed it was made watertight by placing canvas over the exterior of the sheeting and the cofferdam and crib pumped out. On the first attempt the cofferdam unfortunately was not sufficiently strongly braced to withstand the head and a failure occurred, but on the second attempt the crib was successfully refloated and was found to be entirely undamaged. The tops of the cribs when set were just above high water (as shown in Fig. 11). They were filled with sand, gravel and other material obtained from outside sources and a superstructure wall built completely around the pier, the 2 ft. spaces between the cribs being bridged by concrete slabs which were not rigidly attached to either crib but were left free to move in the event of any settlement, although to date no visible settlement has occurred. The space over the cribs enclosed by the superstructure wall was then filled with gravel with the exception of a concrete pipe trench in which the various pipe lines were housed below deck level, this trench being bridged over by a removable timber cover.

To provide for slight inaccuracies in setting the cribs the superstructure wall projected over the cribs a theoretical 12 in. on all sides, though in practice this 12 in. varied from about 9 in. to 15 in., creosoted timber walings shaped to fit the cribs being first placed to bring the base of the wall to the correct line, these walings being attached to the crib by T-headed bolts in slots to provide for easy removal and replacement when required.

The whole of the deck of the pier with the exception of the pipe trench is paved with a 6 in. concrete slab laid on the fill and a timber coping runs completely around the structure. The approach trestle, in addition to carrying the pipes, also carries a 10 ft. truck roadway as it is sometimes necessary to run trucks out on to the pier for handling barrel shipments. The approach roadway to the pier was built by the Imperial Oil Company's own forces, and all pipe lines were also laid by them, the remainder of the work being carried out by the E. G. M. Cape Company of Montreal.

Of the work described in this paper, Pier "B" transit sheds and the reconstruction of Pier 2 were designed and supervised, under the direction of the author as consulting engineer, by the Harbour Commission staff with Mr. C. S. Bennett as chief engineer. The remainder of the Harbour Commission work was designed by the Commission staff, the author being consulting engineer in an advisory capacity during construction. In the case of the dock for the Imperial Oil Company the author was consulting engineer for the company, as this work did not come under the Commission.

# The Outardes Falls Power Development

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**Paper presented at a joint meeting of The Institute and the American Society of Civil Engineers in Boston, October 6th, 1937.**

**SUMMARY.—The paper describes a 65,000 hp. hydroelectric development with an 18 ft. pipe line 5,960 ft. long and two turbines working at 208 ft. normal head. The design had to meet somewhat unusual conditions as regards location and operation.**

Through the initiative of The Ontario Paper Company of Thorold, Ontario, Mr. A. A. Schmon, President and General Manager, there is now in process of creation, on the north shore of the Gulf of St. Lawrence, about 200 miles below the city of Quebec, an entirely new and modern industrial community, listed in the postal directory under the name of "Baie Comeau." This community will be supported by a newsprint mill, now under construction for an initial rated output of 320 tons per day, which will draw the bulk of its wood supply from The Ontario Paper Company's limits in the basin of the Manicouagan river. The Ontario Paper Company is a wholly owned subsidiary of the Chicago Tribune and the Daily News of New York, which newspapers it supplies with newsprint. The towering figure of Colonel Robert R. McCormick, publisher of the Chicago Tribune, stands behind the entire project.

The new mill being inaccessibly located with reference to existing electric utility systems, it was necessary for the Ontario Paper Company to locate and develop its own motive power supply as an integral element of the scheme. The site chosen for this purpose is about 14 miles westward of the mill-site at Outardes Falls. This site is on the Outardes river, immediately adjacent to tide-water, and appears to be the eastern terminus of a series of important natural water-powers, created by the final plunge of the Laurentian rivers over the hard southern edge of the Precambrian Shield, which extends westward across the Province of Quebec through Montmorency, Shawinigan, High Falls on the Lievre, Chelsea on the Gatineau, to Chats Falls on the Ottawa at the Ontario boundary.

The Outardes Falls itself exists as a reach of river something over a mile in length, through which, by way of one main and two subsidiary channels, the waters pass over a series of falls and heavy cascades, the lower ones discharging direct into tide-water. The natural fall over this reach is about 190 ft. at normal high tide.

Work on this project was commenced in 1926, by the company's own engineering staff at the home office in Thorold, under the direction of Mr. Jules T. Jaeger, chief engineer, and later with the Power Corporation of Canada as consultants. When active operations were temporarily suspended in 1932 all of the permanent elements of a concrete main dam and intake had been completed. During this period also there was built and used a small hydro-electric installation. This plant is located at one of the lower cascades, and is again being used as a source of power for construction purposes.

Active operations on the project as a whole were resumed in March of 1936 under the same auspices, so far as the engineering work was concerned, but with Mr. John Stadler of Montreal as general consultant. On account of an accelerated progress schedule, and space limitations in the Thorold engineering office, the engineering and designing staff of H. G. Acres and Company, at Niagara Falls, only seven miles distant, was incorporated for the time being as a unit of the Thorold organization, with Mr. Jaeger retaining the title of chief engineer in respect of both organizations. Under this arrangement, all of the economic and layout studies, all of the specifications and contract plans, and all phases of the subsequent engineering and design detailing relative to the Outardes power development were handled in the offices of H. G. Acres and Company, while all similar procedure relative to the mill, townsite and woods operations was handled in the company's engineering office at Thorold.

Actual construction work commenced at Baie Comeau and Outardes Falls with the opening of the 1936 working season, under the direction of the company's own field engineering staff, and with The Foundation Company of Canada in charge of construction operations.

The completed main dam being already in existence, as previously explained, the matter of conception, design

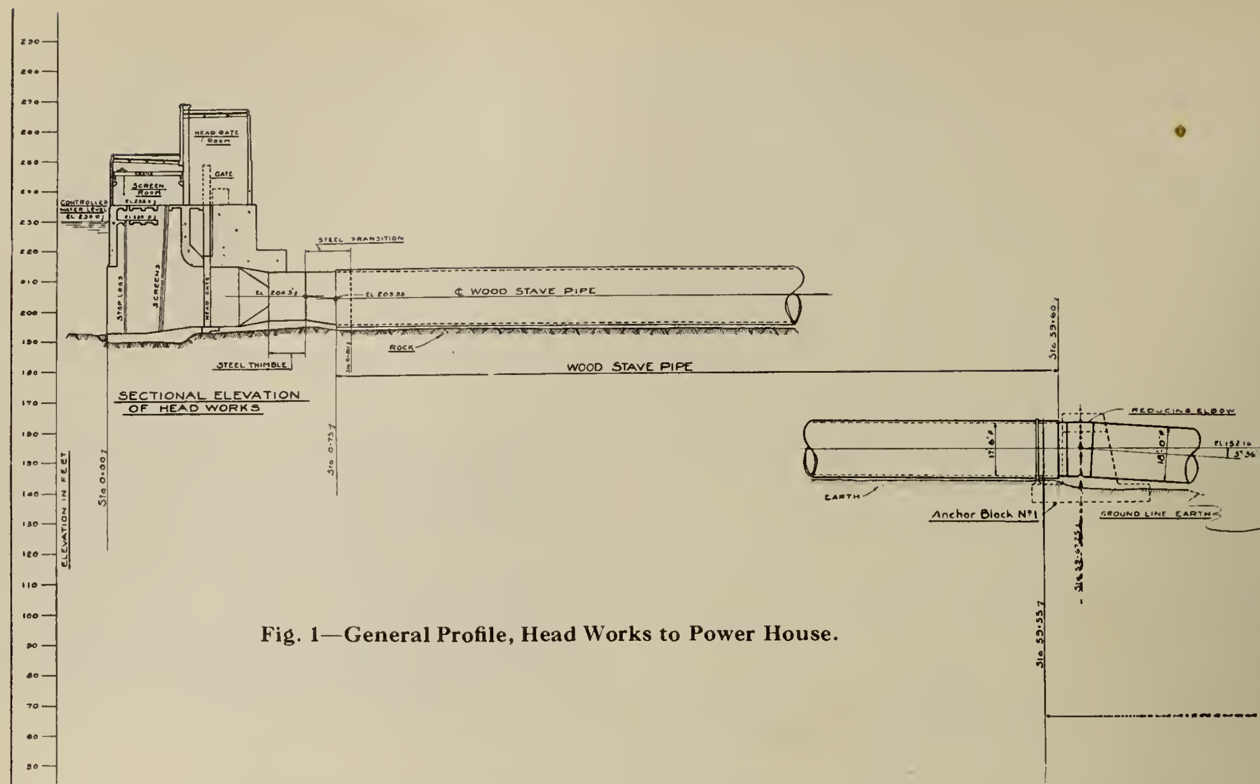



Fig. 1—General Profile, Head Works to Power House.

and construction involved the remaining major elements of water connections, power-house and tailrace, main and auxiliary machine installation, transmission line and step-up and step-down transformation.

The conception and design of the above elements of the scheme were governed by the following primary considerations:—

(1) The industry at Baie Comeau has an assured raw-material supply, and an assured and stable market for its total rated output, so that an adequate, dependable and continuous source of motive power was an outstanding consideration, by reason of its extraordinarily direct influence upon the fixed-charge and overhead elements of mill production cost.

(2) Owing to the fact that the operating system comprised an isolated and single source of power, supplying an isolated and single consumer with a large block of power to be applied almost wholly on industrial load, inherent hydraulic and electrical stability constituted the paramount consideration associated with the technical design.

(3) In order to make good the time schedule prescribed by the Ontario Paper Company, and in view of the fact that the site is only accessible for the delivery of equipment and construction material for the period May to November, inclusive, in each year, it was necessary to take into consideration and to study conditions, relative to conception and design, which are not ordinarily associated with a project of this type.

The general profile, Fig. 1, indicates the topographical features which fixed the general principle of the design. From the intake location down to station 59+60 the drop in adjusted gradient is 51.8 ft., indicating the economic advantage of an open pipe-line under a static head limitation which made it possible to consider wood-stave construction.

From station 59+60 to the power-house the increased gradient, and the necessity for a rather deep cut through the overburden at the crest of the hill, involved the consideration of some material other than wood for this section of the pipe-line.

The total length of pipe-line from intake to power-house is 6,580 ft., so that surge control was an unavoidable feature of the design. The surge-tank was located at station 63+76, for the primary reason that at this point occurred the most suitable and accessible outcrop of ledge for the tank foundations. The second advantage of this location is that it enables the surge-tank to exercise control over 96 per cent of the total length of the water column, with a proportionately large measure of relief to the duty on the turbine governors.

The above combination of economic and physical conditions constituted the basis upon which the details of layout and design had to be developed.

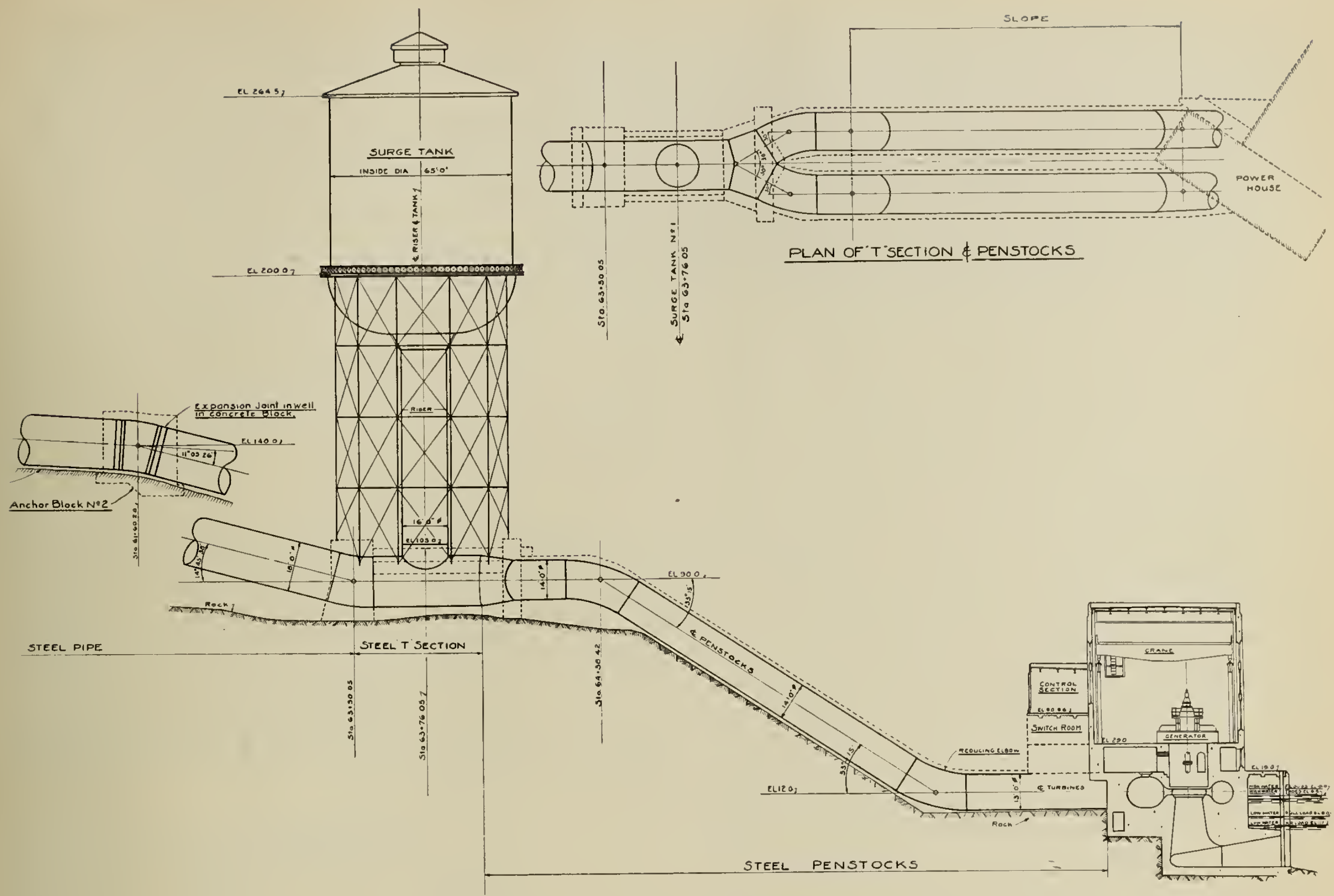
### Available Head

The gross head continuously available was of course fixed by the relationship between tailwater elevation at high tide and the regulated level in the headpond, as governed by the structural features of the main dam, already in place. The relationship as thus fixed made available a gross head of 222 ft.

It was found, after giving consideration to the various factors involved, one of which was the primary necessity of obtaining at all times an ample supply of motive power for the Baie Comeau mill, that the allowable economic sacrifice of gross head would be about 14 ft., so that the normal effective head on the wheels was fixed at 208 ft. at high tide.

### Available Flow

At the time the study of flow conditions was made, continuous records of the daily flow of the Outardes river at the power-site were available for an 11-year period, 1923-24 to 1928-29, and from 1930-31 to 1934-35, inclusive. These records are shown in condensed form on Fig. 2 in terms of average monthly flow for the period. This curve shows a minimum recorded monthly flow to have occurred in February of the year 1924, and that later, in March of




1926, there occurred a minimum which was substantially the same as that of February, 1924.

About 75 miles above the power-site there is a lake storage available, which could be developed for a gross capacity of not less than four billion cubic feet. The effect of this storage is also shown on Fig. 2 by the dotted lines subsidiary to the curve of natural flow.

A further and much larger increment of storage is also available at the head-waters of the river, which would make available a large additional block of primary power.

It is not necessary to elaborate on the flood flow conditions of the Outardes river, as the discharges within the flood range are beyond the limits of economic development, and are interesting only insofar as they are related to the ability of the main dam to safely control and dispose of them.

In this latter connection the records reveal two significant facts: the first being that the maximum recorded peak flow is 85,800 sec. ft., and the second being that the peak flow in every year of record does not occur for a considerable time after the initial winter break-up, the primary reason for this condition being that the Outardes river flows generally in a southerly direction.

### Available Power

Figure 3 is complementary to Fig. 2, and shows the power available from the recorded monthly and daily flows under a normal effective head of 208 ft. Here again the additional primary power obtainable from immediately available lake storage is shown by the dotted lines subsidiary to the curves derived from natural flow.

This figure indicates that 39,500 e.hp. is available from the minimum monthly run-of-river flow, and 52,100 e.hp. of primary power from run-of-river flow supplemented by the immediately available increment of storage, as above mentioned.

### Intake

The intake, the substructure of which was built with the main dam, consists simply of two main openings, each having three bays protected by a curtain-wall and three sets of removable steel racks. Only one of these main openings is being made use of at the present time, the other being temporarily bulkheaded by stop-logs, reinforced by a steel plate diaphragm laid on the rack supporting beams.

In the other main opening, and behind the racks, are placed two roller-mounted, steel head-gates, which are raised by a stationary motor-operated hoisting mechanism, and which in emergency can be tripped electrically from the control-room in the power-house and dropped by gravity.

A substantial superstructure building has been provided to house the hoisting mechanism of the gates, and to permit the effective use of artificial heat under low temperature conditions.

At the rear of the main opening, now being made use of, is an embedded steel thimble to which the pipe-line will be attached.

### Wood Stave Pipe-Line

This pipe-line is 5,960 ft. in length, and the subgrade consists mainly of a mixture of sand, loam and clay. In the upper half of the grade occur several outcroppings of ledge and two comparatively short filled embankments.

As the result of a series of soil bearing tests it was found that the natural soils along the subgrade had bearing values well within the limits of economical footing design,

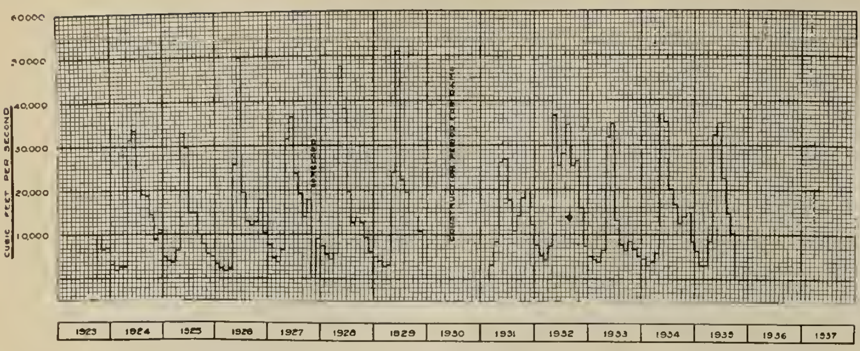


Fig. 2—Outardes River Average Monthly Flow.

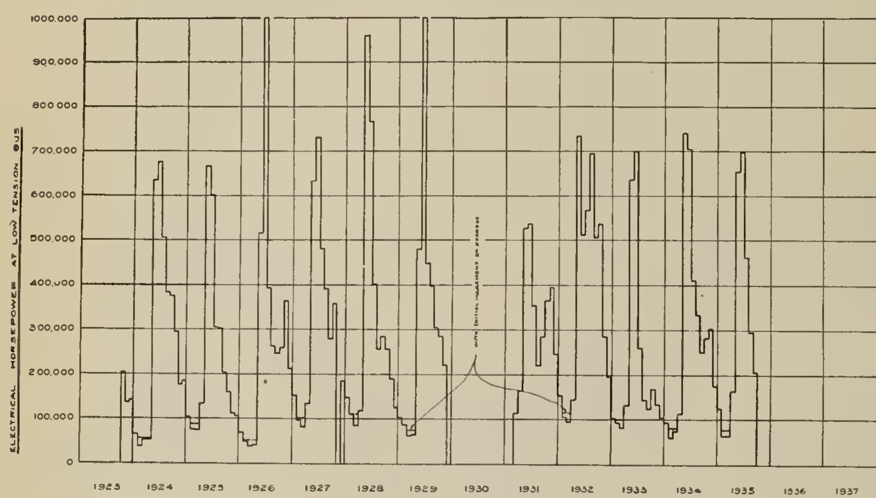


Fig. 3—Outardes River Available Power.

but that the filled embankments could not be relied upon without the help of piles. These piles were driven either to rock or sufficiently deep into the natural soil subgrade to assure the required bearing value. Tapered cast-in-place piles were used for this purpose, 258 in all being placed, in length ranging from 7 to 35½ ft.

The wood-stave pipe has an inside diameter of 17 ft. 6 in., and will be the largest diameter pipe of this type built up to the present time. The staves are special grade Douglas fir, $4\frac{11}{16}$ in. thick, with double-tenon butt joints, tongued and grooved edges, and faces milled to the radius of the pipe. The bands are of one inch diameter, medium grade structural quality steel, with malleable cast-iron shoes. The barrel of the pipe is supported on reinforced concrete spread footings and structural steel cradles spaced on 9 ft. centres. An assembled section of the pipe-line, saddle and footing is shown on Fig. 4.

The wood-stave section of the pipe-line terminates at station 59+60, as shown on Fig. 1, immediately upstream from a heavy concrete anchor block which constitutes an element of the junction between the wood-stave and the steel section of the pipe-line.

### Steel Pipe-Line

The steel pipe-line begins at the anchor block at station 59+55, and thence through the cut in the overburden at the crest of the hill down to station 64+07, where it terminates in a Y-branch immediately below the surge-tank tee.

This section of the pipe-line is supported in part on ledge and in part on spread footings, spaced at approximately 22½ ft. intervals, in combination with intervening reinforced concrete struts, which terminate in a combined thrust and anchor block located on solid ledge, and integral with the surge-tank foundations and the reinforced concrete structure enveloping the surge-tank tee.

The principle of design used for the steel pipe-line is that of the elastic theory of thin membranes or the so-called "shell theory." Analysis by this theory shows that the main stresses in the pipe plates are direct tensile and compressive stresses and shearing stresses, bending stresses being very small. The exemplification of this theory requires that the pipe be kept truly circular and this has been accomplished by providing ring-shaped steel plate girders, 18 in. deep at approximately 22½ ft. centres. Short posts at each end of the girder horizontal diameter provide a means of support whereby the load is taken to the footings.

Since only direct and shearing stresses govern the design of the pipe plates, and bending stresses are concentrated in the ring girders, metal can be used with great economy and a large saving in tonnage effected.

On each side of the anchor block, located at the central bend, a slip-type expansion joint has been provided. These expansion joints we considered essential in order to reduce thermal stresses in the pipe shell to a minimum and to relieve the central anchor of the large lifting forces which would otherwise obtain. Foundations for this anchor are on soil, since ledge rock was known to be at a depth of about 45 to 50 ft. below the natural grade.

For the joint purpose of frost protection and of stabilizing the slopes of the cut at this point, the lower-half circumference of this steel pipe will be given a protective coating and backfilled. The upper-half circumference will be protected by an insulated housing.

### Surge Tank

The surge tank is of the Johnson differential type, with an outside riser 16 ft. in diameter, and a tank 65 ft. in diameter. The main tank is supported on a 12-legged tower, and the completed structure will be 200 ft. 9 in. high from the horizontal centre-line of the surge-tank tee to the peak of the roof.

The whole of the outside riser and the dish bottom of the tank up to the gallery floor are to be insulated by a layer of rock wool with a weather-proof outer coating. The tank roof is to be similarly insulated.

A non-spilling tank of this type, correctly proportioned, affects in a positive and absolutely non-failing fashion those hydraulic changes in the water column, which, acting together with the turbine adjustment, are required to maintain equilibrium between power developed and system load demand. At the same time the tank affords the maximum of protection against dangerous water hammer pressures.

### Penstocks and Valves

The two penstocks now to be installed are 14 ft. in diameter, and, after entering the rear of the power-house substructure, each terminates in a 13 ft. diameter butterfly valve.

The subgrade of these penstocks is entirely in ledge, being at the grade of the natural surface at the Y-branch and in a cut about 55 ft. deep adjacent to the power-house. On this account the footing design was very simple, and involved nothing beyond supporting the pipe at its designed grade during the process of assembly.

As in the case of the steel pipe-line, the penstocks are of steel plate, welded throughout, but without expansion joints. Upon completion of assembly they will be encased in concrete and the rock cut will be backfilled.

The wickets of the butterfly valves are of annealed cast steel and are provided with horizontal trunnions. The seal is effected by renewable bronze segments fitted in an annular groove at the periphery of the wicket and seating on a stainless steel surface electrically deposited on the housing.

The housings are of one-piece construction, fabricated by electric arc welding from rolled plates and ribs, and after fabrication were stress-relieved in a furnace sufficiently large to accommodate the entire housing.

The operating cylinders are mounted vertically and are actuated by oil pressure, at 300 lb. per sq. in., which is controlled from two stations. One of these is a push-button in the control-room for closure only, and the other is a control stand located on the generator-room floor, from which point the valve can be either opened or closed by manual operation of an hydraulic valve. Suitable indicators, interlocks, and signal lamps have been provided.

### Turbines

The available net head at the Outardes site was such that the total motive power requirement of the Baie Comeau project could be concentrated in one main unit. This was obviously the most economical arrangement from the standpoint of subsequent operation as well as the first cost of that portion of the installation, as a whole, which included water connections below the surge-tank and the power-house structure with its contents.

Inasmuch as the already established market outlet for its products permitted the Baie Comeau mill to operate continuously at full rated capacity, the elimination of stand-

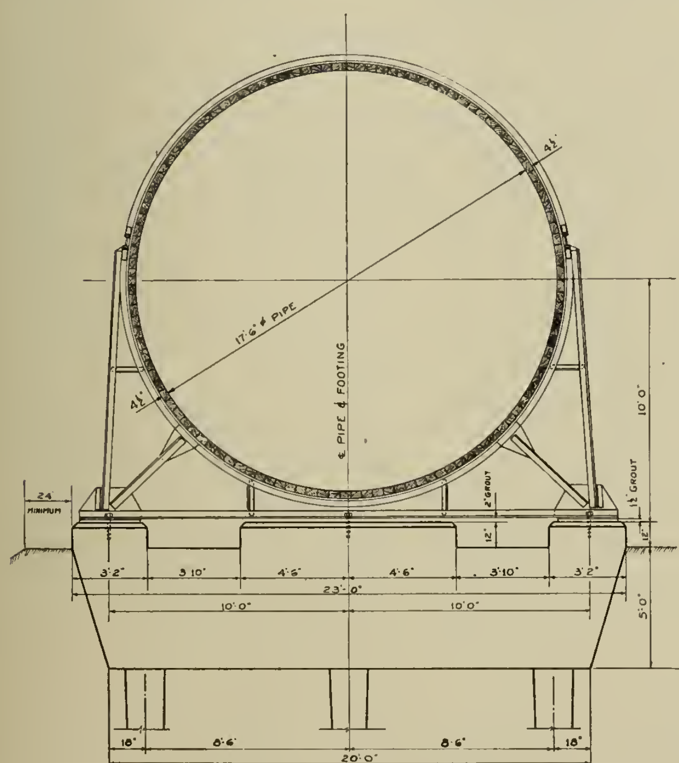


Fig. 4—Typical Section Wood Stave Pipe.

by losses resulting from interrupted operation and the realization of a maximum rate of return on invested capital became almost directly dependent upon an adequate and continuous supply of motive power. The imposition of this vital function upon the source of power supply was, in itself, sufficient justification for providing at the outset for the installation of a duplicate spare unit.

Associated with these primary considerations were two conditions peculiar to the site itself. During the winter the Outardes river, for a distance of approximately 200 miles above the power reach, is subject to ice blockages which temporarily obstruct the flow and result in short-period irregularities and deficiencies in the supply reaching the headpond.

The headpond, in turn, is small, having an area of only 1,750 acres, so that there will be a comparatively large and rapid headpond draw-down necessary in order to make good temporary deficiencies in flow due to ice blockage.

With the intake as now designed and built, a maximum draw-down of 15 ft. can be accommodated without exposing the lower line of the curtain-walls, and advantage was taken of this fact to specify a turbine so designed and dimensioned as to be capable of producing the total motive power requirements of the Baie Comeau mill under a temporary minimum net head of 193 ft.

The final consideration under this head arose out of the fact that the construction schedule made it necessary to have the power-house substructure completed up to the level of the turbine deck not later than August of 1936, and inasmuch as the work of layout and design did not get under way until March of that year, there was no time to wait for final layout drawings from the turbine contractor. It was therefore necessary to design the lower sections of the power-house substructure complete, and to require turbine manufacturers to bid and base their guarantees upon a definitely fixed draft-tube design.

Accordingly, the specifications called for two vertical, single runner, steel plate scroll-case units, turning at 180 r.p.m., each unit being so dimensioned and designed as to produce 32,600 hp. under the minimum net head of 193 ft. Under the normal net head of 208 ft., each of these turbines will deliver 35,300 hp. at the main coupling.

The turbines, as now being constructed, have a diameter of 11 ft. 2 in. at the scroll-case inlet, a shaft diameter of 24 in., and a maximum out-to-out diameter of 32 ft. The salient features of the turbine installation are shown on the cross-section, Fig. 5.

### Generators

The basic design of the generators was fixed by the simpler characteristics of the load. The six-day weekly load-factor was specified as not less than 90 per cent, and the synchronous load of the mill was such that operation could be maintained continuously at 95 per cent power-factor lagging at rated speed and voltage. As 25,000 kw. at the generator terminal were sufficient for the motive power requirements of the mill, the specifications called for a rated capacity of 26,315 kva.

Two water-wheel type generators were therefore provided for, each having the above specified capacity at 6,600 volts and 180 r.p.m. These generators were of the two-bearing type, with top mounted thrust bearing and direct-connected exciters, 3 phase, 60 cycles, star-connected. The estimated revolving weight of this unit, inclusive of turbine runner and shaft, is 135.5 tons. The general dimensions and outline are shown in Fig. 5.

### Electric Steam Generation

The process steam requirements of the Baie Comeau mill will be such that, under ordinary circumstances, it would be necessary to install three fuel-fired, steam generating units, any two of which would have sufficient capacity to carry the mill load. This would be necessary in order to give the process steam supply the same assurance of adequacy and continuity as was associated with the supply of motive power.

In this connection it was considered that the spare generating unit at the Outardes plant could properly assume the function of a steam generating unit without impairing its utility as a duplicate source of motive power supply, so that in place of a third fuel-fired steam generating unit at the Baie Comeau mill there was substituted for it an electric steam-boiler installation of sufficient capacity to take somewhat more than the total output of either one of the main units in the Outardes plant. So far as capital costs were concerned, this electric steam unit at Baie Comeau simply took the place of a third fuel-fired unit which would otherwise have been installed, while, as to annual cost, the economy of this scheme was measured by the annual saving in coal consumption which would result from the carrying, continuously, of something over half of the process steam requirements of the Baie Comeau mill, by the Outardes spare unit, while at the same time not interfering with the stand-by function of this unit as a source of motive power supply for the mill.

### Transformation and Switching

This element of the installation was, of course, not as vitally involved in the matter of an assured supply of motive power as the turbines and generators, but it was nevertheless a distinct advantage, as related to the short-period interruptions to which apparatus of this class is ordinarily subjected, to have it also installed in duplicate. Having in mind, however, as explained in the next preceding section, that the scheme of operation required both main units in the Outardes plant to be continuously under full load whenever they were in condition to operate, the installation of transformation and switching equipment in duplicate was not only advantageous but definitely necessary.

The transformation and switching at both the generating and delivery ends are of the outdoor type throughout.

The transformer installation at the power-house consists of two 3-phase, 60-cycle banks and a spare, stepping up from 6,600 to 66,000 volts. Each of these banks has a capacity of 25,000 kva. and each is connected to its own generator.

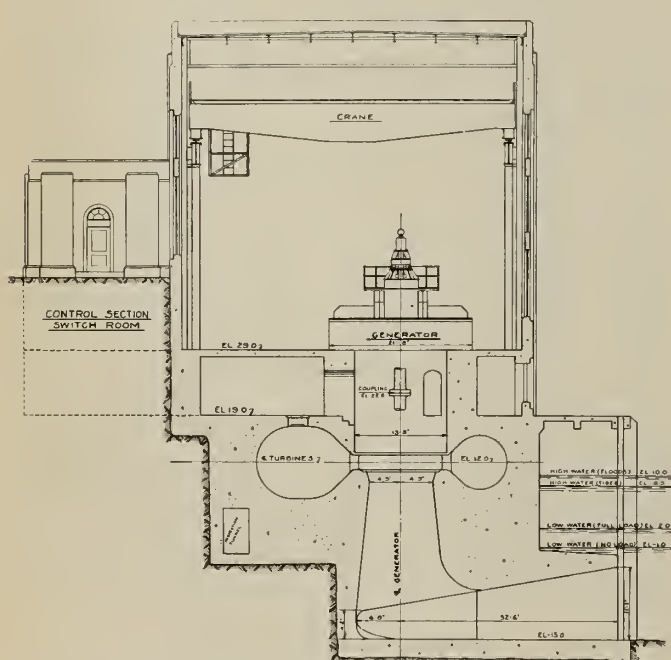



**Fig. 5—Cross Section of Power House Showing Arrangement of Main Unit.**

At the mill substation are installed three 3-phase, 60-cycle banks and two spares. One bank and spare steps down from line voltage to 4,600 volts for electric steam generator service, and one bank down to 2,300 volts for grinder-room service, and the third bank and spare down to 575 volts for general mill service, the 4,600 volt spare transformer being also available for 2,600 volt service if necessary.

All transformers are water-cooled and designed for a full load temperature rise of 50 deg. C. They have a reactance of 7 per cent, and are to be star-connected on the high, and delta on the low-voltage side, with neutrals solidly grounded. All are provided with four 2½ per cent taps on the high-voltage side, so that proper operating voltage may be available at the mill under all conditions of load.

To obtain the greatest economy and flexibility from the switching equipment, the stations at each end of the transmission line were designed as a ring bus system and all switching, except station service, is done on the high-voltage side of the transformers. Such an arrangement permits any one breaker in the ring to be removed for repairs without seriously affecting the operation of the station, but two breakers must be opened if any line or transformer bank is to be isolated.

The oil circuit breakers are of the high speed type, with a rupturing capacity of 500,000 kva., and oil-blast explosion chamber contacts. Each breaker consists of three single-phase tanks equipped with oil-filled bushings, and each tank is provided with two 500-watt heaters. They are solenoid operated by remote control from a control-room inside the power-house or paper mill, the power supply being obtained from a 125-volt storage battery. All breakers are interchangeable in the ring bus, and have bushing type current transformers of the same rating for metering and relaying.

Lightning arresters and impulse spark gaps are provided at each end of each transmission line to limit the potential rise to safe values during transmission line disturbances.

The buses and disconnecting switches are supported on galvanized steel structures, which were shop assembled before galvanizing so as to ensure ease of erection with a minimum of damage to the galvanizing.

Figure 6 shows, in half section, the general arrangement of the step-up transformer and switching layouts, respectively.

This structure is located at the south end of the power-house, with its floor about 12.75 ft. above the machine-room floor.

The high-tension ring-bus layout made it convenient to place one transformer bank, with its associated breakers, on either side of the transformer transfer track, and underneath this track there is space provided in the form of a tunnel, having a floor at the same elevation as the machine-room floor, for the power and control cables, water, oil piping, etc. The oil piping is so arranged that oil from the transformers or breakers will flow by gravity to the filter without in any way disturbing the apparatus.

A large door has been provided in the power-house south wall, through which the transfer track is extended to a gallery floor in the machine-room which is within reach of the main hook of the power-house crane. This arrangement provides convenient facilities for transformer substitutions and repairs. It is also thereby possible to store the spare transformer inside the building, thus eliminating the necessity of keeping it heated during the winter months.

As the low-tension cable leads to the generators are nearly all indoors, it was advisable to form the transformer delta near the generators instead of at the transformers. On account of the heavy low-voltage currents, six power cables per unit were required, and these were all placed inside the transformer delta connections, thereby dispensing with the usual transformer delta bus.

### Transmission Line

The route of the transmission line is, for the most part, through wet shallow muskeg with a sand bottom, and occasional ledge outcrops. Under such conditions the matter of footings for the line supporting structures became a problem of structural design, which, for simplification and standardization, required that the number of footing structures be reduced to a minimum. This consideration definitely eliminated wood pole construction and indicated an advantageous use of long spans supported on steel towers.

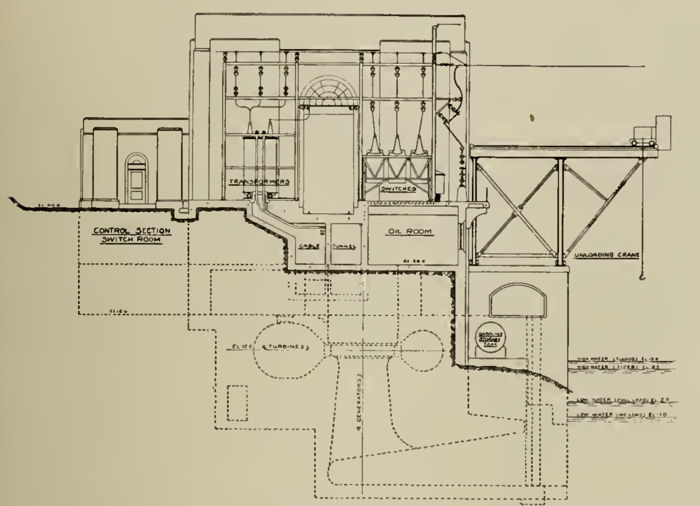


**Fig. 6—Sectional Elevation, Transformer and Switching Station.**

As the initial and future load conditions were closely defined, the line characteristics were susceptible of fairly precise determination, and an extensive comparative analysis was made of various voltages, conductor sizes and materials, etc., in order to derive a rational economic balance relative to capital cost, annual cost and line loss, assuming from the start the necessity of two 3-phase circuits to assure the continuity of service which the primary elements of the problem as a whole required.

This study resulted in the adoption of two circuits of 266,800 c.m., A.C.S.R. conductor, star-connected for 66,000 volts phase to phase and 38,100 volts phase to ground. The two circuits in parallel will carry the total station rated output of 52,360 kva. with a regulation of 3.25 per cent at 99.28 per cent power-factor, and one circuit will perform the same service with a regulation of 6.75 per cent.

The conductors are supported by suspension type insulators on double-circuit steel towers. The towers have a nominal spacing of 800 ft., and have a total height of about 80 ft. above the ground line. A 3/8-in. steel ground wire is carried on the tops of the towers, and there are a total of 82 towers of the various types required in the 13½ miles of line.

A graded highway is now under construction between Baie Comeau and Outardes Falls, which follows as closely as possible the transmission line route. This highway is being utilized for the erection of the line, the material for which was delivered in the fall of 1936 and distributed along the line during the following winter.

### Power-House

Rather unusual conditions were associated with the location and design of the power-house, relative to the position of underlying ledge, and the location of the pipe and penstock centre-line.

The only available location for the power-house was in the face of a practically vertical cliff, at the foot of which was a narrow parallel shelf of solid ledge dropping off vertically in turn into saturated sand and gravel of unknown depth. The obvious expedient under the circumstances was to minimize the heavy rock cut in the face of the cliff by laying out the nose-line of the tailrace piers parallel with and along the edge of this subsidiary shelf of ledge. The position of the power-house building was therefore fixed by the primary necessity of making use of solid ledge at the lowest natural elevation which the site afforded, and the secondary but important consideration of simplifying as much as possible a more-than-ordinarily expensive piece of rock work.

As previously mentioned, the rock cliff at the power-house location was surmounted by a steep slope of overburden consisting of a sub-stratum of blue clay, covered in turn by a thick layer of well-drained sand. The problem of supporting and holding an 18 ft. diameter steel pipe on this slope was governed by the following independent considerations, in order of their importance: first, the locating of accessible natural ledge to serve the double purpose of a solid foundation for the surge tank and a strong anchorage for the thrust-block at the terminal elbow of the steel pipe-line; second, a minimum of disturbance to the natural equilibrium of the overburden slope as a result of such excavation as might be necessary; and third, the confining of the excavation as much as possible to the sand overburden, with a consequent minimum of disturbance to the clay sub-stratum. The position of the steel section of the pipe-line was therefore fixed, as in the case of the power-house, by the joint influence of topographical conformation of the site and the foundation conditions.

The position of these two elements of the scheme having been thus fixed, the location of the penstock centre-line was also of necessity established, and instead of meeting the power-house rear wall at right angles, as is usually the case, it intersected the longitudinal centre-line at an angle of 34 degrees and 28 minutes. This complicated the basement layout to such an extent that it was necessary to make a ¼ in. scale model in order to properly visualize the valve-chamber clearances and the shape and volume of usable basement space which was required for piping, wiring and auxiliaries. Special provision had also to be made for bridging the wide skew opening in the northwest corner of the rear wall in order that the building con-

**Fig. 7—General View of Outardes Development.**

struction might proceed in advance of the erection and concreting-in of the penstocks.

The power-house building is of sufficient size to house the first two main units only, with auxiliaries. A temporary end wall is provided so that the north end of the building can be extended to accommodate any additional installation in the future.

The substructure is of reinforced concrete throughout, the foundation elevation being such that the draft-tube inverts are about 23 ft. below the level of ordinary high tide.

The frame of the superstructure is of structural steel with concrete encased columns supporting the crane girders, roof trusses and purlins. The walls are of reinforced concrete and the roof of Aerocrete slabs surmounted by a 20-year specification tar-and-gravel roof. Copper flashing is used throughout, and all construction joints are sealed with copper water-stops.

Apart from the complications arising from the entrance of the penstocks at an acute angle with the power-house centre-line, as already described, the only other unusual feature of the power-house structure arose from the fact that all heavy equipment had to be delivered on scows. In order to place this equipment within reach of the main hook it was necessary to provide for an opening in the power-house front wall, opposite the erection bay, and at the floor elevation of the machine-room main floor. The erection-bay floor was extended through this opening and out over the tailrace piers, which supported it, with flush rails at transformer gauge embedded in it. On this exterior platform there was erected a cantilevered steel framework supporting a 22½-ton motor-operated trolley hoist, by means of which loads were lifted from the scows, landed on the platform, and either trucked or skidded through the opening where they could be reached by the main hook. The general arrangement is shown in the section in Fig. 6.

### Auxiliary Equipment and Services

The most important items of auxiliary equipment are the turbine governors and the stop-log and sluice-gate hoists for the main dam.

Each main unit has its own individual oil pressure governing system, the actuator, oil pump and sump tank being designed as a unit and enclosed in a steel cabinet, on the face of which the controls and indicators are mounted.

The actuator flyball head is driven by a synchronous motor which receives its power supply from its own independent permanent magnet generator. This generator is mounted on the pilot exciter frame, and is driven through two flexible half couplings by the main unit generator shaft. The flyball head must therefore rotate in exact synchronism with the speed of the unit to which it is electrically connected, and will not be affected by any other electrical or mechanical condition.

The governor operating fluid is oil at a pressure of 300 lb. per sq. in., the pressure tanks being located immediately adjacent to their respective cabinets. The oil piping, however, will be interconnected so that in the event of trouble with one of the pumps it may be isolated and both governors will continue to operate under power pressure. No recourse need be had to the hand pump under such circumstances.

Each actuator is provided with the following manual controls located on the cabinet panel face: speed level, gate position limit, speed droop, generator air brake valve, and the transfer valve which permits operating the servomotors through either the auxiliary valve or the main relay valve. In addition, remote control of the speed may be accomplished from the bench-board in the control-room.

There is one pressure tank and one receiving tank only for both butterfly valves. As the demands on the valve oil pressure system are light, and are usually made at predetermined times, a separate oil pump for this service was dispensed with, and the butterfly valve oil pressure system was arranged for interconnection with either of the turbine governor pressure systems. A small transfer pump returns oil from the butterfly valve receiving tank to either of the governor oil sumps.

The main dam was provided with six roller-mounted steel crest gates operating in openings 10 ft. wide with sills 30 ft. below controlled water level. These are for headpond control, and are manipulated by a 16-ton electrically operated trolley hoist. There are, in addition, eight 30-ft. openings, with sills 10 ft. below regulated water level, which are to be closed by combination steel and timber stop-logs. These logs are to be placed or removed by a 25-ton electric stop-log machine of the rack and pinion operated spud type.

Two sluice and pier dams, known as "Dam A" and "Dam B," were built to close out neighbouring low rock contours. The former has thirteen, and the latter six 30-ft. openings. The stop-logs and stop-log machine are similar to those provided for the main dam, except that the latter has bogey trucks to negotiate the curve on Dam A and that between the two dams.

An auxiliary and emergency service unit was considered necessary on account of the isolated location and the low winter temperatures from which the plant, as a whole, must at all times be protected. A gasoline engine set offered the best combination of convenience, dependability and economy, and the installation consists of a 425 hp., 900 r.p.m. engine direct-connected to a 550-volt generator with its own individual exciter, rated 250 kva. at 80 per cent power-factor. This generator is connected through an automatic oil switch to the 550-volt station service bus, so that any station service load may be supplied from this unit, as well as from either of the main generators.

There has also been provided a stand-by M.G. exciter set, which consists of a 1,200 r.p.m., 500-volt, A.C., 250 hp. motor direct connected to a 150 kw. direct current generator and a 3 kw. pilot exciter. The generator and exciter circuits are arranged so that they can be connected at the control desk to either main generator and voltage regulator.

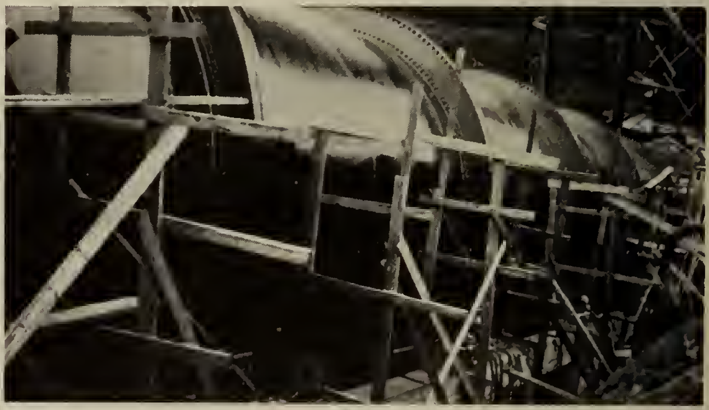


Fig. 8—18 ft. dia. Steel Pipe Showing Ring Girders and Struts.

The station service load is divided into two primary elements, and each element is served by its own transformers and control equipment. The more important of these is the station service supply to the governor pumps, cranes, spare M.G. exciter set and other auxiliary equipment in the power-house, and to the building heating and lighting. The other element, served by a 150 kva. bank of transformers, supplies power at 2,200 volts to the intake gate hoist and dams, which are located about 1 mile from the power-house.

Each generator bus is tapped by a separate feeder for this load, and the two breakers are interlocked electrically so that both feeder breakers cannot be closed at the same time, thus obviating the possibility of paralleling the generators on the low-voltage side of the transformers. The service high-voltage switching consists of a metal clad structure of four units, one unit for each generator feeder, and one unit for each element of the station service load. The breakers are rated 6,900 volts with a rupturing capacity of 250,000 kva. (sufficiently large to take care of the ultimate station generating capacity) and a short time current carrying capacity of 50,000 amp. The tanks and covers are of welded plate steel, and the contacts are of the oil blast principle, so as to reduce the arcing time to a minimum.

The power-house station service transformers consist of a bank of three 150 kva., single phase transformers, stepping the voltage down from 6,600 volts to 550 volts. The intake and dam station service transformers consist of three 50 kva. transformers stepping the voltage down from 6,600 to 2,200. Both banks are connected delta-delta so that if trouble develops in one transformer, the bank, connected in open delta, may carry on at reduced capacity. The transformers are of the standard distribution self-cooled type.

The 550-volt distribution switches are of the "Nofuz" breaker type for all of the motor and feeder circuits, except the stand-by exciter motor circuit, which switch, on account of its large capacity and infrequent service, is of the fused vacu-break type.

A storage battery has been installed for the primary purpose of controlling the oil circuit breakers, but also as a source of power for emergency lighting, and to supply power to a few small miscellaneous pieces of apparatus. It is the standard type of storage battery used for such purposes, consisting of 60 cells, and operating at a nominal potential of 129 volts.

Duplicate battery charging sets are provided, one as a stand-by to the other. They consist of a 5 hp., 60 cycle, 550-volt motor direct connected through a solid coupling to a 3 kw., D.C., shunt-wound generator. All signal lamps and certain emergency lighting circuits will be connected to the battery permanently, so as to provide sufficient load to hold the generator voltage steady.

As previously stated, a tunnel is located underneath the centre of the switching station for power cables, control conduit and oil and water piping for the transformers and breakers. Adjacent to this tunnel, at the south end of the building, is located an oil storage and filter room containing separate tanks for clean and dirty transformer and breaker oil.

A system of piping has been provided whereby oil may be transferred to or from the transformer or breakers to the proper tank or to the filter for purification, and thence back to either clean oil tank. This filter, with its centrifuge, is capable of handling 300 gal. per hr., and is equipped with a heater and motor-driven pump. Each transformer tank contains 1,280 gal., and each breaker tank contains 300 gal. of oil, thus making a total of 11,280 gal. of active oil to be served.

Combination steel and timber stop-logs have been provided for unwatering the turbine draft-tubes. They are manipulated by a gantry-type hoist travelling on the tail-race deck. The hoist is electrically operated and provided with a mechanical follower for engaging the logs.

During the normal operation it is expected that the interchange of water between pipe-line and surge tank, associated with the tank insulation previously described, will prevent ice forming on the water surface therein. During the first winter, however, the mill load will consist only of heating and town service, so that the above

Fig. 9—Concrete Encased Penstocks, Surge-tank and Steel Pipe Line.

condition could not safely be assumed. To take care of this condition an air bubbler system has therefore been provided for in the surge tank, which consists of two rings of pipe, drilled to form a series of nozzles. One of these rings is fastened to the interior of the lower part of the tank bowl, the other to the inside of the base of the internal riser, and both are connected to the station service air compressor receiver in the power-house. This air compressor is located at turbine deck elevation and is a single stage machine compressing 120 cu. ft. of free air per min. to 100 lb. per sq. in. gauge pressure.

An 8 in. connection to both penstocks just upstream from the butterfly valves makes an ample supply of water for station service available at all times. Because of the known fact that the river water carries large amounts of extremely fine silt in suspension, a complete filtering system has been installed in the basement of the control section.

For the coarser material, duplex strainers fitted with coarse and fine screens have been provided. To remove the extremely fine material, the water can be treated with suitable coagulants and passed through a series of mixing chambers and a settling tank.

No heating system has been provided which will heat the power-house completely during a shutdown period, but 5 kw. electric heaters have been distributed throughout the building at important points, such as near the governors, in the oil-room, etc., and these heaters will be supplied with power from the emergency gasoline generator set during any period of total shutdown.

Normally the building will be heated by circulating warm air from near the ceiling of the generator-room, through the control section and back to the generator pit. This is accomplished by means of a system of ducts leading from the ceiling of the generator-room to an exhaust fan located in the control section. This fan transfers the warm air, under pressure, to another duct system and distributes it to the various rooms of the control section. The air then passes downward to the turbine floor, whence it is drawn into the generator cooling system and re-heated. Regulation and tempering of the air are accomplished by the proper manipulation of doors within the building, and by a system of louvres in the south wall of the power-house.

### Speed Regulation and System Stability

The consideration of this problem was based primarily upon the following fixed elements of the general scheme:—

(1) A topographical conformation of the site which necessitated the inclusion in the development scheme of an active water-column 6,580 ft. long.

(2) A system load of the order of 65,000 hp. of maximum demand at 90 to 100 per cent working-day load-factor, divided approximately in the proportion of 30,000 hp. of steady non-inductive base load supply for electric steam, and the balance of 35,000 hp., inclusive of a negligible proportion of municipal load, for mill motive requirements, about 70 per cent of these latter requirements being synchronous.

(3) A close coupled self-contained system of production and use which will never have available to it the stabilizing influence of a transmission network connected to diversified sources of supply and varied classifications of consumer demand.

(4) A large single block of generated power supplying a single consumer with wholly industrial load over a short transmission line of low impedance.

Associated with the above fixed elements of the problem were the following desired operating conditions and requirements:—

1. A limiting speed variation of 2 per cent (1.2 cycles) up to a 10 per cent instantaneous swing in the motive power load.
2. Both main units and both high-tension lines in parallel on station and mill high-tension bus.
3. In the event of a disturbance on any one line, the functioning of relays and switches to be sufficiently fast and precise to effect the transfer of the total station load to the other line without serious disturbance to the machine drives in the mill, and without the necessity of dumping the electric boiler load.

As related to any one transmission circuit, it was recognized that by far the most frequent source of interruption would be single-line to ground faults; that line to line faults or double-line to ground faults would be a possible but relatively infrequent source of interruption; and that three-phase shorts were more of a station than a line hazard, and would in most cases cause an unavoidable system outage.

Fig. 10—Cinching and Spacing Bands on Wood Stave Pipe.

Fundamental to the realization of the above operating conditions and requirements was of course the control of the water-column. The means by which this was effected within the limits of feasible design has already been described.

Associated with this fundamental limitation, as to surge-control in the pipe-line, was the fact that the fastest breaker, in connection with which an acceptable guarantee is obtainable, is one which functions within 8 cycle limits.

It was therefore necessary to realize the desired operating conditions and requirements to the fullest extent possible within these two primary limitations.

Fig. 11—Completed Wood Stave Pipe.

As to speed control, it was found that with the surge-tank functioning as intended, the turbine governors would be able to regulate within the desired speed limits if each main generator had a fly-wheel effect of 10,000,000 "*WR* squared." This was accordingly called for and provided.

Principally in view of the large proportion of synchronous load to be handled, the realization of inherent system stability required:—

1. A high short-circuit ratio (low reactance) in the generators, associated with a high pull-out torque on the synchronous load.
2. High speed excitation as an adjunct to automatic voltage regulation.
3. Over-voltage control as an adjunct to high speed excitation.

The generator specifications called for a short-circuit ratio of not less than 1.25, and this value was incorporated in the accepted design. High speed excitation in this design took the form of a main exciter unit with a motor-operated bridge type field rheostat and a pilot exciter of 7½ kw. capacity with a back-of-board type of field rheostat. Over-voltage control and protection were effected by relaying across the pilot exciter terminals, and cutting in resistors in the shunt fields.

As an additional precaution under this head, each main generator was equipped with pole-face windings, which, while primarily affording lightning protection, have a beneficial influence on dynamic stability.

Thus designed and equipped, and with the system operating at full load with generators and lines in parallel at both ends, it was found that a condition of transient instability would be reached in 0.22 sec., or 13.2 cycles, in the event of a single-phase line to ground fault near the load end. This is well within the 8-cycle time element of the breaker plus the relay time, for the end nearest to the fault, but the clearing of the other end will be delayed until the first breaker has opened. This condition only applies to faults in the end zones, because if the fault is out on the line the high speed current and balanced power relays operate within one or two cycles to clear the line at each end.

The operating conditions to be anticipated under such circumstances are therefore:—

(*a*) That the system will ordinarily ride through a single-phase line to ground fault without the necessity of cutting motive load or dumping the electric boiler load.

(*b*) That the system may ride through line to line or double-line to ground faults and remain stable, this possibility being governed primarily by the distance of the fault from the generating end of the line and the amount of load being carried at the time.

(*c*) That three-phase faults anywhere on the system are to be treated as emergencies and not as normal incidents of operation, so that transient instability must be assumed as an unavoidable element of the situation thereby arising.

Relay functioning and protection were divided into four primary zones for study and design: namely, generators, transformer banks, station service, and transmission lines.

The split-phase armature windings of each main generator are protected with relays of the percentage ratio differential high speed type, for both split phase and overall protection, and a ground fault detector is also applied to the complete generator field and excitation system.

The transformers are provided with a differential relay protective scheme in which is included an overall back-up protection from the generator bus to the line side of the transformer high-tension breakers. For this scheme, relays with an operating time of 6 to 8 cycles were provided, which will give satisfactory clearing time to meet the stability requirements of the system.

For the station service transformer banks instantaneous induction overcurrent relays are used, while for the incoming feeders from the generators induction type overcurrent and instantaneous overcurrent relays are provided. These latter relays provide against the closing of these circuits on a bus short-circuit, and by the addition of an auxiliary relay will be rendered inoperative for a short time following energizing of the bus.

The functioning of the transmission-line relay system is dependent upon the potential obtained from potential transformers connected to the low-voltage side of the power transformers at each end of the line.

Ordinarily, both transmission lines are operated in parallel and therefore the current is divided equally between them. The first element of line protection and switch control therefore operates on a constant percentage current unbalance characteristic. This fixed characteristic is essential in order to eliminate unnecessary shutdowns on heavy external short-circuits. The second element of line protection is a combination of relays to protect against simultaneous faults on the same phases of both lines at the same location, in which case there might not be sufficient current unbalance to operate the current unbalance relays. This second combination of relays also provides for single-line operation, for operating two lines separately on the high-tension bus, and also for stand-by protection.

The relays are generally similar at each end of the line, except that balanced current relays are used at the power-house end, while at the mill end of the line balanced power relays are used, since at the mill end the relays must be independent of any back-feed of fault current from the synchronous motors in the mill.

### Grounding

A preliminary survey of both the mill and power-house sites indicated that suitable grounds might be difficult to obtain. At the power-house the sand in the bottom of the tailrace and the water itself were both of high resistance, but by driving ground rods 20 ft. long in the bottom of the tailrace a zone was reached which showed a ground resistance of about 4.5 ohms, which was considered satisfactory.

The mill site at Baie Comeau is predominantly ledge rock, but fortunately there were some mud flats situated about 500 yards from the mill substation, which at high tide are covered with brackish water. Ground rods driven in these flats showed a ground resistance of less than one ohm, and this site was therefore adopted as a permanent ground for the mill and station area.

Nests of ground rods were accordingly driven in the power-house tailrace and in the mud flats at the mill. These were tied together with heavy stranded copper wire and ground leads brought to all neutral points and all electrical apparatus in the stations.

Along the transmission line tower footing resistances are now being taken as the towers are erected. Some footings are known to have a very high resistance, being located on solid rock, and it is possible that part of the line at least will require a counterpoise in order to obtain a sufficiently large flow of fault current to ground to assure positive relay functioning.

### Personnel

The responsible personnel associated with this project is:—

The Ontario Paper Company, Limited:

A. A. Schmon, President and General Manager.
John Stadler, M.E.I.C., General Consultant.
R. W. Shaver, Manager, Comeau Bay Division.
Jules T. Jaeger, Chief Engineer.
W. L. Eliason, Electrical Engineer, Operation and Design.
Dan Anderson, A.M.E.I.C., Electrical Engineer, Operation and Design.
A. I. Cunningham, A.M.E.I.C., Resident Engineer.
R. V. H. Keating, A.M.E.I.C., Assistant Resident Engineer at Outardes.
J. B. Sims, Purchasing Agent.
F. J. Byington, Traffic Manager.
Chas. Warnock and Company, Limited—Inspection.
Allen Engineering Company, Limited—Inspection.

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The Foundation Company of Canada, Limited:

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K. C. Weedin, Superintendent at Outardes.
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Of the above, the writer is indebted in particular to Messrs. Schmon, Andrews, McQueen and Munro for assistance and advice in the preparation of this paper.

# The Substructure of the New Highway Bridge Over the Fraser River at New Westminster, B.C.

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SUMMARY.—After describing the considerations governing the design of the substructure, the paper discusses the construction work, noting the difficulties encountered due to the heavy currents and nature of the site and foundation material.

The new Provincial Government bridge, now well advanced toward completion, will cross the Fraser river opposite the city of New Westminster, the oldest city on the mainland of British Columbia and its former capital. The new structure is to be known as the Pattullo bridge, so named after the present Premier of the Province, the Honourable T. D. Pattullo. The Fraser river at the point of crossing, which is situated twenty miles from the mouth, is about one-half mile in width. The depth of water varies from a maximum of seventy feet near the north bank to about half this depth for the larger portion of the river towards the south bank. The river bed is of alluvial formation, the deposit of sand towards the south bank exceeding one hundred and fifty feet in depth, while a hardpan ledge underlies the bed in the manner indicated by Fig. 2, a plan of the borings.

The current reaches a maximum velocity of eight and one-half miles per hour during the freshet season of June, while a reverse current having a maximum velocity of one and one-half miles per hour is encountered during the period of winter tides. The tidal range, except during the freshet period, is between five and six feet at the bridge site. Due to the heavy discharge of the river all the year around, the water is never brackish and no marine borer action occurs. At infrequent intervals the river freezes solidly at the new bridge site but never to a depth exceeding a few inches. Drift ice to a thickness of 15 ft., however, has been observed to choke the river at this location, and is a factor affecting pier design. The ground adjoining the river bank on the south shore is flat for at least a mile, being dyked to prevent flooding during the freshet season. On the north shore the ground rises abruptly from the river bank, attaining a height of 130 ft., sufficient for approach purposes, in a horizontal distance of about 500 ft. Muskeg formation from 20 to 40 ft. in depth overlies a sandy formation on the south shore, while a glacial deposit of hardpan and boulders outcrops on the north shore.

The bridge approaches are of reinforced concrete, the south approach being 1,400 ft. in length, reinforced by light welded truss construction, and the north approach consisting of two spans, each 70 ft. in length, with the usual bar type of reinforcement. Earthwork construction connects these approaches with the existing highway system. The bridge proper is shown in Fig. 1 and is of high level type consisting of a series of Warren deck trusses of two lengths, namely 200 and 250 ft. The main and central portion of the superstructure consists of three spans of continuous construction, the central span a tied arch 450 ft. in length with flanking spans 350 ft., similar to the Honore Mercier bridge at Montreal. The clearance under the central span for navigation purposes is 150 ft. above normal freshet level. The deck consists of a reinforced concrete slab 40 ft. of roadway width providing four lanes of traffic, while a six foot sidewalk is provided on the downstream side of the bridge. Welded steel handrails are provided both for approaches and bridge proper, and steel lamp standards will carry sodium vapour lighting. The bridge deck is designed for uniform live loading of 80 to 100 lb. per sq. ft. and concentrated loading of 20-ton trucks, with three-fourths of the load on the rear axle. As far as applicable, Canadian Engineering Standards Association specifications govern.

### Factors Governing Design

Before selecting the present site of the bridge, surveys and preliminary estimates were made of possible sites, between the mouth of the river twenty miles below and Port Mann, four miles above the final location. These sites were abandoned because of cost of approach roadway systems and the fact that the existing combination railway and highway bridge at New Westminster, which had established the main route south and east, had outlived its usefulness for highway traffic purposes. As the existing bridge at New Westminster has not heretofore been mentioned, it should be explained that it consists of a two-deck low level combination bridge, completed in 1904, from plans by Messrs. Waddell and Hedrick. The upper or highway deck was not designed for modern vehicular traffic, the width between curbs being slightly under sixteen feet. A proposal to strengthen the bridge as a whole and widen this traffic deck was considered but abandoned as it was felt that only a high level bridge would fill the needs of the very near future. As the old bridge is also owned by the province and is very necessary to the three railways who operate thereover, it was finally decided it should remain, but that the highway deck should be removed on completion of the new structure.

It will be seen that due to the proximity of the two bridges in a channel which carries a substantial deep sea traffic and a heavy tug, barge and tow boat movement, the selection of the location of the piers of the new bridge was greatly influenced by the position of those of the existing bridge. Under the direction of the District Engineer of the Public Works Department of the Federal Government, J. P. Forde, M.E.I.C., an enquiry was instituted as provided by the Navigable Waters Protection Act. A public hearing at New Westminster, at which all interests were represented and heard, resulted in the recommendation and selection of the present site, 200 ft. downstream from the old bridge. The authorization of the construction fixed the location of Piers 2, 3, 4 and 5 within such narrow limits as to practically determine their positions. At this point, namely in November 1935, the author was appointed by the Minister of Public Works for the Province, the Hon. F. M. Macpherson, to make surveys, obtain borings and test pile data and proceed with the preparation of plans and specifications and estimate the cost of the new project.

Borings in the river bed, as shown in Fig. 2, disclosed hard material available at practical depths for a distance of 350 ft. from the north bank. From this point southward to Pier 8 river sand of varying consistency was encountered to an indefinite depth. It was immediately apparent that Piers 3 to 8 inclusive must rely for their support on the bearing value of the sand plus friction on piles or caissons or both. Samples of the sand foundation disclosed a safe bearing value of 4 tons per sq. ft. and a frictional value of 600 lb. per sq. ft. The first studies were directed towards pneumatic caissons for Piers 1 and 2 and open caissons with pile pockets for the remaining piers. However, after the consideration of many factors, amongst the more

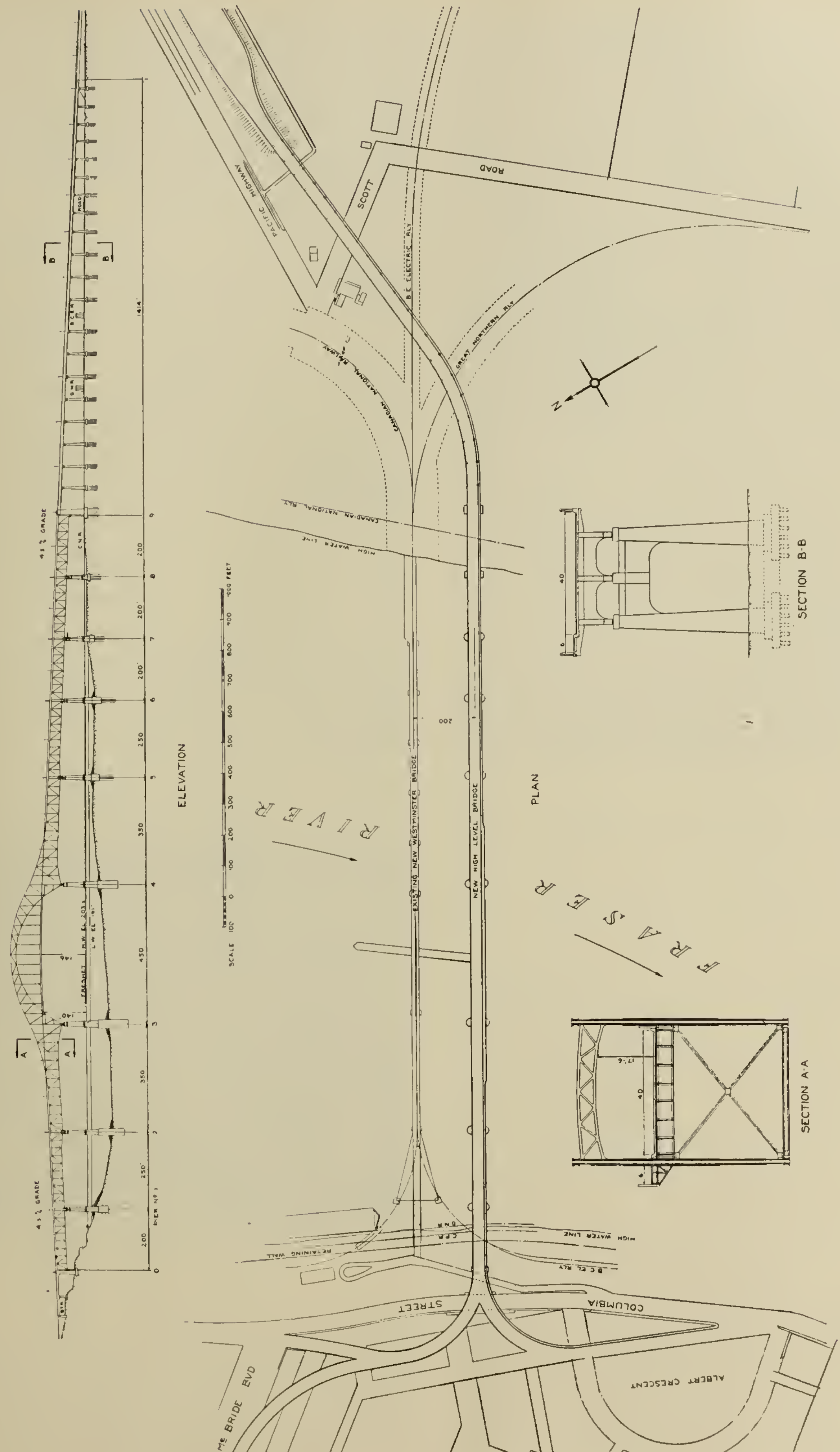


Fig. 1—General Plan of Bridge.

important being the practical depth at which bearing piles could be driven and figured with confidence, it was decided to adopt open caisson construction for Piers 2, 3 and 4, because of the excessive depth of water, and employ cofferdam construction on Piers 5, 6, 7 and 8 coupled with bearing piles for foundation purposes. Eventually the expense of air equipment for Pier 1 caused a decision to be reached providing for an open caisson job at this pier.

The firm of Messrs. Monsarrat and Pratley, bridge engineers, of Montreal, were employed by the author to advise on the foundation problem and their experience and advice were invaluable in the earlier studies and in the final designs adopted. A study of Pier 3 is covered by Mr. Pratley as follows (see Fig. 3):—

"The total weight of the pier with low water buoyancy reaches 24½ million lb., so that with the superimposed load of 6½ millions, about 31 million lb. is to be taken care of by bearing area and friction. The area of the base is 2,850 sq. ft. The friction on the outside surface only, at 400 lb. per sq. ft., amounts to between 5 and 5½ million lb. The friction on the inside surfaces of the wells A and C at 300 lb. amounts to about 3½ million lb. For these figures the unit pressure on the full bottom regardless of friction, is exactly 5½ tons per sq. ft. The outside friction reduces this to exactly 4½ tons. If the inside friction is also allowed, the unit is reduced to 7,770 lb. The punching load, therefore, on the bottom at the elevation of the cutting edge, −35, which is the total bearing unit, minus the natural pressure on the undisturbed sand at the same depth, is a very low and conservative figure. The design indicated on the sketch shows penetration down to −35 for the purpose of developing an ample friction and for presenting an amply large surface against the sand for resistance to horizontal moments. The figures on the latter question indicate that for longitudinal loads such as wind and friction at the bearings, but excluding ice and current, the pressures between the sand and the vertical surfaces of the caisson are sufficient at very low units to resist all horizontal moments. For horizontal forces in the other direction, transverse to the bridge, where ice and current pressure are included together with wind on the superstructure, the live load, and the pier, the vertical surfaces of the caisson submerged in sand will develop unit pressures against the natural sand which are well within permissible figures before any tilting effect can reach the cutting edge to increase the vertical punching units."

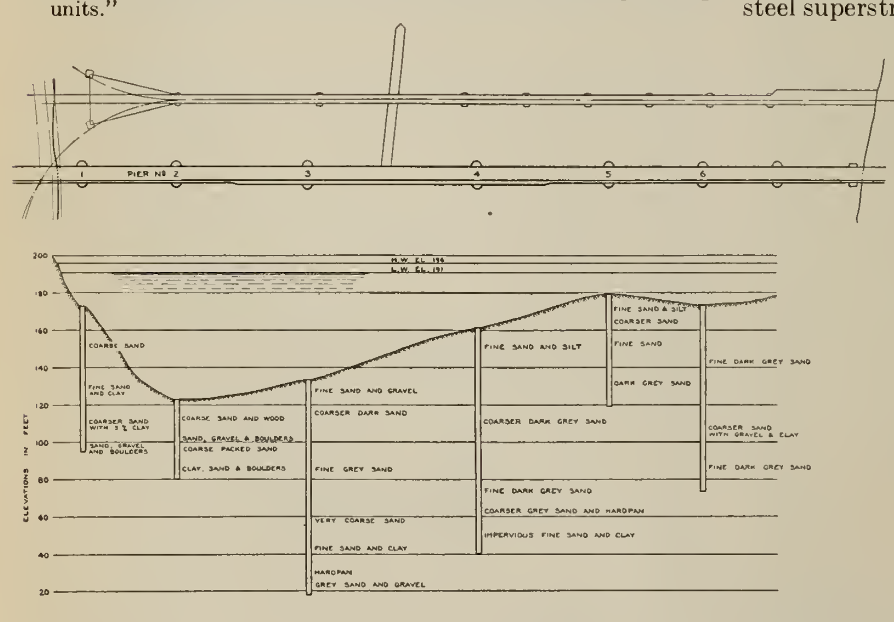


Fig. 2—Plan of Borings.

Alternative types of construction for the foundations which were studied and abandoned, covered the proposed use of large reinforced concrete cylinders for Piers 1 to 4 inclusive to be built in place with fixed forms and moving cylinders supported on false work piling during construction. The hazard of the heavy current alone caused this type to be discarded. Open cribs of horizontal courses with caulked joints and with cutting edge and pile pockets were also considered for Piers 5 to 8 inclusive. The sinking of these and probable scour during the sinking operations provided a problem that left doubt as to their successful use, and was the reason for their rejection.

As was to be expected from the nature of the foundation material, the north approach to the bridge is founded on hardpan with spread footings, while the south approach foundations are carried on wooden piling driven and cut-off well below ground water level. These portions of the work are dealt with later in some detail.

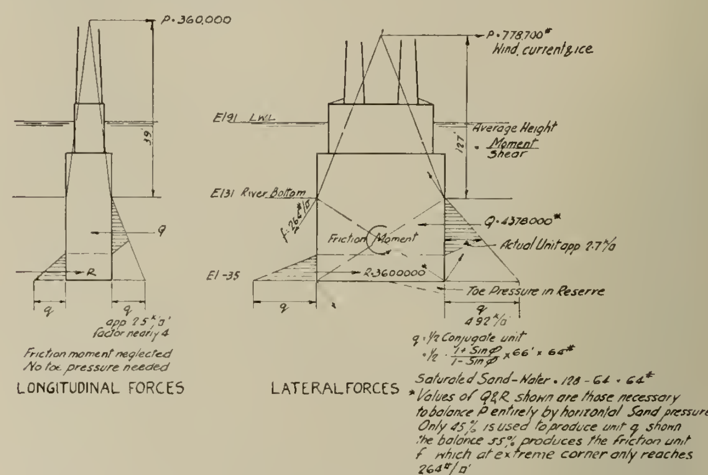


Fig. 3—Study of Pier No. 3, Lateral and Longitudinal Forces.

### Estimated Cost, Tenders and Contract

Final plans, specifications and estimates were submitted to the Chief Engineer of the Public Works Department on April 30th, 1935, and approved for tender. It was decided to call for tenders on a unit price basis for all foundation work, combined with a lump sum price for the steel superstructure. This list embraced nearly one hundred subdivisions for pricing and was felt by the Public Works Department to provide greater elasticity in ordering minor changes in the work during construction. The total estimated cost of the work was $4,000,000, which figure included right-of-way, property damage, legal and engineering expense. This sum was voted by the provincial parliament and funds made available accordingly. At this writing it would appear that the completed cost will be well within the statutory sum.

Tenders were called on April 30th, 1935, closing date being set June 10th, 1935. Two tenders were received, of which the lower from the Dominion Bridge Company Limited, amounting to approximately $3,250,000. was accepted. The successful bidder included in its figure that of the Northern Construction Company and J. W. Stewart Ltd., for the substructure and approaches, and the latter firm carried out this portion of the contract. The contract was signed August 21st, 1935.

### Piers 1, 2, 3, and 4

The contractor obtained a site for the construction of the caissons on the north bank of the river one mile above the bridge site. Here an old wharf existed which was repaired as a mooring wharf and adjoining a launching ways was constructed. The depth of water alongside was 30 ft. at low water and the channel to the bridge site provided a minimum of 30 ft. at high tide. The caissons could and accordingly were completed to a stage where they drew 29 ft. before towing to place. Steel cutting edges similar to that used for No. 1 caisson (and shown in Fig. 4) were erected on the launching ways and the caisson built to such a height as to provide a safe margin of stability in the launching operation. The sequence of caisson construction selected by the contractor was in the order 1, 4, 3, 2, beginning with the simplest operation and ending with the most difficult. This arrangement permitted experience to be gained by the contractor's personnel as the operations became more difficult. An outstanding example of how this worked out may be judged by the fact that the false bottoms of No. 1 caisson required ten days for removal, while in the case of No. 2, which is double in size, the same operation required but three days. Similar experience was observed in the rate of sinking after the cutting edges had entered into the river bed.

The construction of the caisson is depicted in Fig. 5, which is a plan and cross section of caisson No. 3. The framework is of the usual timber construction, sheeted with 3 by 12 in. fir planking with caulking groove, the joints butted for caulking. Concrete outside and partition walls are four feet in thickness less intrusions of timber brace frames. This concrete, designed for a strength of 2,500 lb. per sq. ft., was all poured in the dry. Caissons Nos. 2, 3 and 4 included a central longitudinal wall, while in No. 1 this was unnecessary and omitted. Dredging pockets in the larger caissons were 11 by 14 ft. and 11 by 12 ft. with triangular end pockets, the latter large enough to permit convenient operation of an orange peel bucket.

Concrete was poured in the cutting edge sections before launching and in every instance concreting was continued at the mooring wharf until a draft of 29 ft. had been reached. This provided a proper measure of stability necessary for towing to the pier sites. At the sites, pile enclosures strongly constructed, one end open and accurately located, were prepared to receive the caissons. Caisson No. 4 grounded in towing, without damage, was refloated at high tide and placed the following day. All other caissons

Fig. 4—Cutting Edge for No. 1 Caisson.

were towed to sites without mishap. In the case of caissons Nos. 1 and 4 these were completed including concreting at the mooring wharf, but due to the much greater depth of water, caissons Nos. 2 and 3 had to be completed at their respective sites before grounding. In each case the grounding was accompanied by scour at the upstream nose varying from three to five feet. Gravel was kept under load to deal with this situation and placed by sealing

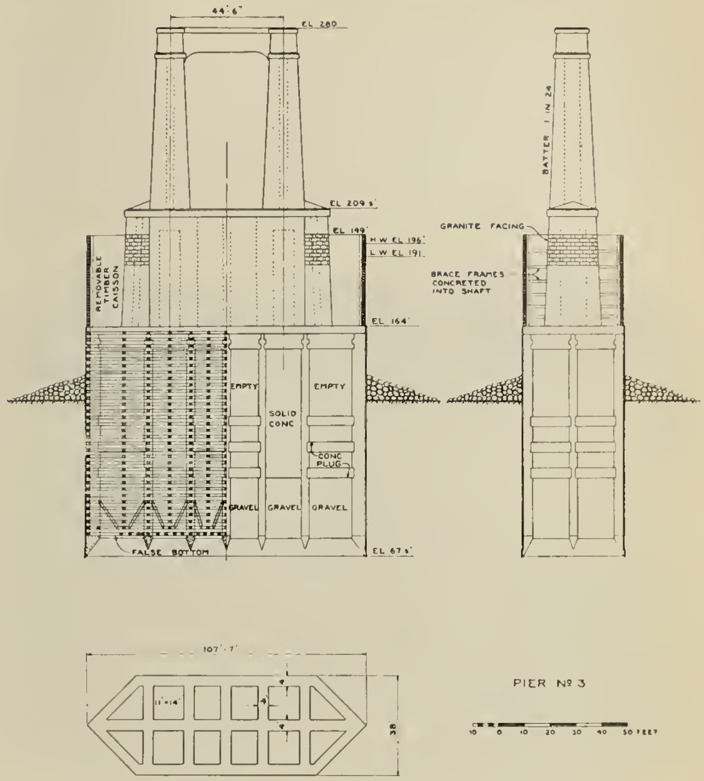


Fig. 5—Pier No. 3, Showing Caisson.

bucket as soon as the caisson was well grounded. Caisson No. 4 had to be raised and reset; all other caissons were accurately set at first grounding.

The following is a log of commencing the construction of, launching, placing and sinking caissons 1, 2, 3, and 4:—

| Caisson | Start Cutting Edge | Launched | Towed to Site | Grounded | Sunk to Finish Elev. |
|---|---|---|---|---|---|
| No. 1 ........ | 27 Dec. '35 | 28 Jan. '36 | 30 June '36 | 30 June '36 | 25 Sept. '36 |
| No. 2 ........ | 17 Aug. '36 | 16 Oct. '36 | Nov. '36 | 24 Dec. '36 | 17 Apr. '37 |
| No. 3 ........ | 30 May '36 | 15 July '36 | 3 Sept. '36 | 14 Oct. '36 | 3 Mar. '37 |
| No. 4 ........ | 10 Feb. '36 | 23 Mar. '36 | 17 Apr. '36 | 17 Apr. '36 | 20 Oct. '36 |

It will be noted that a considerable period of time elapsed between grounding and completing sinking No. 4 caisson. The reason for the delay was due to the extreme freshet conditions of the summer of 1936, which for a time seriously threatened the safety of the partly completed work on Piers 4 and 5. This situation will be dealt with later in some detail.

Sinking operations provided some interesting situations. Plans provided for sinking No. 1 caisson to cutting edge elevation of 135. At elevation 152 hard material was encountered and it required two months of continuous drilling and shooting to permit sinking to elevation 144, at which it was founded. Although considerably above desired level, selected as a safeguard against erosion of the north bank of the river, it was felt reasonable safety attended this decision. The bearing value of the foundation was at least eight tons per sq. ft. and accordingly all pockets were concreted in from the cutting edge level upwards. This caisson was finished with a maximum error in location of nine inches.

At a depth of 15 ft. below river bottom, caisson No. 2 brought up on a 30 in. cottonwood log, which appeared in four pockets parallel to and six feet inside the south side of the cutting edge. Almost a week was needed to shoot and chew away with orange peel bucket before this obstruction was removed. The entire operation at No. 3 caisson was the answer to a maiden's prayer. Grounding, removal of false bottoms and sinking proceeded without mishap. Figure 7 shows this caisson in place. It was never more than twelve inches out of level and on completion the maximum error in location was less than four inches. Caisson No. 4 had a rather hectic experience: it grounded in towing, suffered an extreme freshet and finished nineteen

**Fig. 6—No. 4 Caisson Before Grounding.**

inches from location as maximum error. All caissons were set within allowable tolerances of location, which were fixed at twelve inches for No. 1, eighteen inches for No. 2, and two feet for Nos. 3 and 4. With respect to correction of position of caissons by tilting during sinking operations, it was found that in the class of material encountered in the river bed, no correction worthy of consideration was obtainable after penetration had reached a depth of 20 ft.

It will be noted in the caisson design that solid pockets are constructed in the sections lying directly below the pier pylons, to better receive and distribute the superimposed load. Originally it was planned to fill these pockets with concrete to their base, but this arrangement was revised to ensure a more uniform compacting and bearing over the entire base of the caisson. Figure 5 indicates the nature of the pocket filling.

The manner of placing the gravel and sand filling and the concrete plugs and seals will be of interest. Sand, and gravel in the case of No. 3 caisson, were placed in all pockets by use of sealing bucket, to prevent segregation. The consistency adopted for this filling material was a 20 per cent excess of sand over gravel voids. The concreting followed immediately, a twelve-inch seamless steel tube with flange connections being the tremie pipe. In the case of No. 3 caisson this pipe was 94 ft. in length. It was, as will be judged, too long to permit plugging at the outlet to allow charging and lowering, both because of length and weight. A charge of excelsior was used to plug the tremie pipe immediately below the hopper. This is done by hand and must not be packed too tightly, otherwise it will not permit the flow of the charge. It worked out satisfactorily and it is interesting to note that in all tremie operations where concrete was poured under water covering the entire project, the charge was lost on only three occasions. Laitance to the depth of less than two inches was observable on completion of sealing Piers 1, 2 and 4, while in 3 about six inches was found. Hosing off the top of seals only was necessary and the concrete was of excellent quality and in appearance like a conglomerate formation.

The cofferdams for these piers were placed in three sections. They consisted of 12 by 12 in., 12 by 14 in., and 12 by 16 in. British Columbia fir timbers caulked and well braced with brace frames of similar dimensions. The brace frames were placed at intervals varying from three feet for the lower courses to seven feet for the top two sets of frames. The cofferdams gave no trouble from leakage excepting at the corner joints. To stop this leakage, cinders were fed into the joints from outside and canvas and wedging on the inside of the cofferdam combined in every case to reduce the total leakage to less than 400 gal. per min.

As referred to above, the three section construction was combined with holding down bolts which permitted the removal of the cofferdam in three operations. The specifications provided for the removal of brace frame timbers in courses, as the pier shafts were built. There were in all nine sets of brace frames. To carry out the specification meant at least seven separate breaks in pouring the shafts inasmuch as it provided for the removal of brace frame cross timbers as pouring proceeded. A revision of this clause of the specifications provided that seven of the nine cross frames might be concreted in the shaft construction and the ends of these timbers were cut off flush with the outer face of the shafts. No timber in shafts will occur above a horizontal plane within nine feet of low water level. This arrangement speeded up the operation very materially without detracting appreciably from the finished work.

PIERS 5, 6, 7 AND 8

These piers extending from the south bank of the river are, in the case of 7 and 8, sited practically on shore at ordinary stages of the water, while Piers 5 and 6 are in comparatively shallow water (see Fig. 8). The log of the borings (Fig. 2) indicated a material suitable for pile foundations. Test piles indicated that at 35 ft. of penetration a bearing load of 25 tons was quite safe. Actually

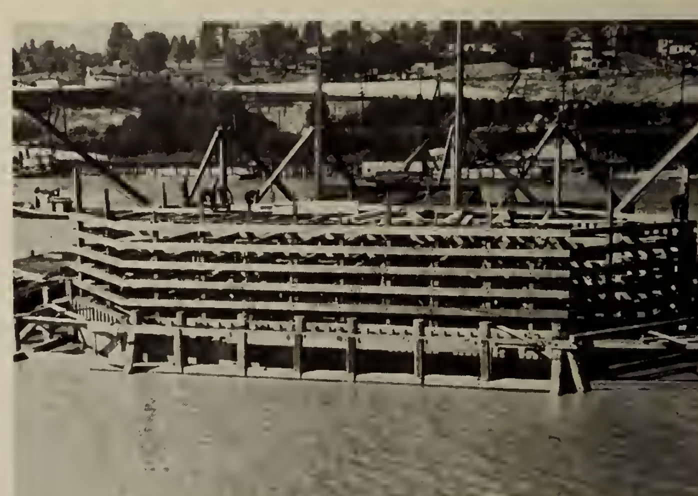

**Fig. 7—No. 3 Caisson at Site.**

the design provided average loading of from 19 tons at Pier 8 to 23 tons at Pier 5. Under extreme conditions of wind, live load and ice, a maximum load of 26 tons may be developed on the end piling, but as a precaution the larger piles were selected for these locations.

The pier sites were first levelled, and guide piles (in the case of Piers 5 and 6) driven, after which heavy brace frames were placed by counterweighting against buoyancy. The contractors elected to drive a single row of wooden sheet piling, twelve inches thick with a four inch tongue and groove, all of solid timber. The millwork was excellent and the fit exceptionally good. The engineering staff, including the author, were sceptical of the ability to satisfactorily unwater this design. Double timber waling at low water level and at the top of cofferdam level held the piling in line, steam hammer and water jet were used in driving. No caulking was resorted to, although cinders were fed into the outside joints during unwatering.

On completion of the cofferdam, excavation was carried down to the bottom of foundation slab level. Bearing piles were then driven with steam hammer and follower combined with water jetting. No difficulty was experienced in driving bearing piles accurately to place, except in the case of No. 7 Pier, where some logs were encountered at depth. The spacing of bearing piles was three feet centre to centre measured diagonally, possibly a trifle closer than usual practice but considered satisfactory because of the unusually large size of old growth B.C. fir, which was supplied. A twelve foot seal of eight-sack concrete was then poured by use of tremie. Eight days later unwatering began, and was found to be comparatively simple. Laitance was almost non-existent, the small amount being hosed off.

Six set-ups of tremie were used in Piers 7 and 8, eight in Pier 6 and ten in Pier 5. The seal was lost only twice in these operations. The concrete so deposited was about 18 in. high at tremie positions and the same amount below grade at the walls. High spots were picked or drilled down, piling cut off and a seven foot reinforced slab poured in the dry bringing it up to the base of pier shaft elevation. The balance of the operation, namely the construction of pier shafts and pylons, was comparatively simple, the only delay occurring when the granite masonry noses of pick faced finish were being built; this masonry extends from three feet below low water level to ordinary freshet level, a total height of 12 ft.

Instead of cutting off the cofferdam timbers above the level of the top of the foundation slab, specifications provided for driving this piling down to slab level. The object was to provide a skirt around the bearing piles which would give additional protection in case of unexpected scour. As the cofferdam of Pier 5 was lost during the 1936 freshet, other plans of a similar nature had to be developed here.

It will be noted that throughout the pier construction by cellular design, weight was reduced in pier shafts and pylons to the greatest possible extent commensurate with strength and loading requirements. In some cases this policy may seem to be carried to extremes but it should be noted that form lumber is cheap in British Columbia.

### Piers 0 and 9

These piers need little, if any, explanation. They are monumental in design and appearance, their purpose being to provide a suitable connection or break between the steel superstructure and the reinforced concrete viaducts. Pier 9 is shown in Fig. 9. Their construction is of the cellular type, voids comprising more than 60 per cent of the whole. In general the walls are but 18 in. in thickness with adequate reinforcement. Towards the river, their seeming large appearance is considerably screened by the superstructure steel, while away from the river they are reasonably moulded with the concrete bents and deck. No unusual problems were encountered in the design or construction of these piers. Pier 0 is founded on hardpan of glacial formations, having a bearing value of approximately eight tons per sq. ft., while Pier 9 is founded on fir piling cut off about six feet below ground water level.

### South Approach

The south approach to the bridge consists of a reinforced concrete viaduct 1,400 ft. in length. The soil formation is an overlying cover of muskeg varying in depth of from 20 ft. at the abutment to only a few feet at bent 10. Below the muskeg lies a bed of river sand of good consistency for foundation purposes and of unlimited depth. Piling was the natural form of foundation construction and consisted of untreated British Columbia fir driven generally 40 ft. into the sand, and cut off at least six feet below minimum ground water level. Piling was loaded not to exceed 25 tons per pile under extreme conditions of wind and live load. The general nature and type of construction is indicated by accompanying photographs.

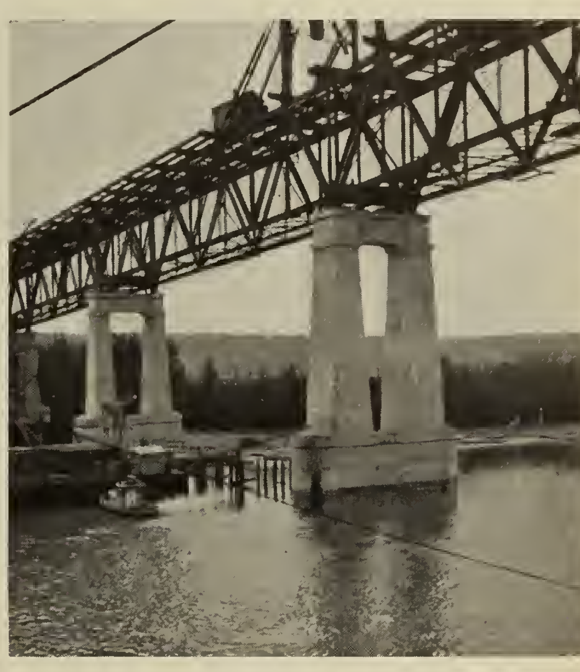

**Fig. 8—Piers Nos. 6, 7 and 8.**

Except in the case of the buried abutment, which was of solid concrete design, all of these bents are of cellular construction. Each bent consists of two cellular columns founded on separate concrete bases in turn supported by piling referred to above. The bases or footings were tied together with a heavy reinforced concrete cross-beam and in turn the tops of the columns combined to support a heavy concrete beam. The central girder of the deck system is carried on a cap built into the middle of the upper connecting beam while the main girders rest on caps which form the tops of columns.

The column walls have a thickness of 15 in., the inner wall being vertical while a batter of 1 in 24 is entirely in the outer wall; this arrangement, which was necessary for economy in design, differs from the pier pylons, which are battered on all faces. Both designs appear to be architecturally correct. The columns of these bents vary in height from 20 ft. at bent 29, to 80 ft. at bent 10. In consequence of the height, the concrete could not be poured continuously. The pouring was carried out as far as possible in lifts of 20 ft., the construction joint being carefully struck to a horizontal line which causes it to be almost indiscernible, due to the fact that form lumber around the columns was also erected in horizontal courses. Figure 9 clearly shows the nature of the forming.

Due to the inferior upper soil texture, considerable thought was given to the design of the abutment. It was felt that some movement in the header bank of the approach fill was inevitable. Solid buried abutment pedestals with broad bases were finally adopted. Filling operations, using sand and gravel, consisted of placing and compacting in layers from ground level upwards to maintain an approximate balance. The results were satisfactory until the autumn rains set in. A subsidence and thrust occurred two months after the abutments had been completed, resulting in a forward movement of nine inches in these pedestal piers, five inches in bent 28, and one-half inch in bent 27. The deck fortunately had not been placed. No movement has since occurred. No registered settlement of the foundations took place. In view of the foregoing, it was decided to extend the viaduct 60 ft. further south and add no further filling material, of which about six feet would have been required to restore the embankment to subgrade level. A composite structure was adopted, the roadway slab, similar to the viaduct, being carried on creosoted timber bents and stringers.

The original deck construction of the south approach viaduct was varied at the contractor's request to permit the use of light welded steel trusses and floor beams designed to carry the construction load without falsework support. This change necessitated the use of a third girder for which provision had to be made in the upper cross beam connecting the columns. The view of this approach (shown in Fig. 9) depicts this construction, which is known in Canada as the "Kane" system.

The specifications provided that all concrete work be given a wash coat of cement grout of proportions, one of cement to two of sand. With few exceptions the finish has been very good and the cement grout wash has been cancelled. The use of vibrators when placing concrete and intensive tamping has been chiefly responsible for a satisfactory finish. A harsh mix of too great a proportion of coarse aggregate has also been avoided at all times. Experience indicated that vibrators, while excellent for producing a dense concrete, were insufficient without adequate tamping to prevent gravel pockets in exterior faces. The slump used in this part of the work was four and one-half inches. Concrete was ready mixed from the contractor's floating plant, conveyed from wharf at river bank to site by light railway in one-yard buckets. The buckets were raised to work by use of dragline equipment, since a

Fig. 9—Pier No. 9 and End of South Approach.

portable tower was impracticable, due to numerous structures, power transmission and other pole lines on the route.

### North Approach

The north approach to the bridge, while less than 200 ft. in length, provided an awkward construction problem, due to highway, street railway, and other municipal services to be maintained. Columbia Street, the principal thoroughfare of the city of New Westminster, had to be re-located. This involved heavy retaining wall construction along the approach to the old bridge, a very busy section of highway. It also involved a partial re-location of the approach in question as Pier 0 was sited in the middle of the roadway. Intermediate bent "A" had to be located midway between Pier 0 and the north abutment in order to maintain width of Columbia Street diversion. This brought the bent "A" foundations on a steep sidehill of clay hardpan, which provides an excellent foundation when dry, but was made difficult by heavy seepage from the hillside. Considerable interceptor drainage was necessary. The footing was carried well into the foundation material, a five foot thick pad used for levelling

Fig. 10—No. 4 Caisson During Freshet.

up at the lower end. The bridge approach begins to flare to meet the two-way connection as soon as Pier 0 is passed. Intermediate bent "A" has, in consequence, an overall length of 70 ft. while the abutment has a length of 225 ft. including wing walls, which are in line with the abutment. Hardpan foundation was also available for the abutment and wing walls, suitable material being encountered from eight to ten feet below ground level.

### Foundation Damage at Piers 4 and 5 and Restoration Programme

The bridge contract was awarded to the Dominion Bridge Company in August 1935, subject to final approval of the structure by the Federal Government under the "Navigable Waters Protection Act." Some time elapsed before the contractor's work in the river was commenced, work on Piers 4 and 5 having been started about the middle of December. Pier 4 caisson was grounded on April 17th, 1936. By May 31st it had been sunk approximately 16 ft. into the river bed. By this date the second heaviest freshet in the history of the Fraser river was well under way, due to a late spring followed by three weeks of excessively warm weather in the interior. Pier 5 was scarcely as far advanced when the crest of the flood arrived. The seal course had been completed, unwatering accomplished and the base course placed. In the short period of ten days the river bottom surrounding the foundations of Piers 4 and 5 scoured to a depth of from 20 to 40 ft. below the original bed level. The cutting edge of Pier 4 caisson was exposed, and the caisson was barely prevented from overturning by placing hundreds of tons of rock under the lower side, which was eight feet out of level. One end of the cutting edge was three feet out of position. Figure 10 shows the condition of this caisson during this freshet.

Pier 5 foundation fared even worse. A pile and timber shearwater above the cofferdam broke loose and punctured the cofferdam. The latter was loosened and undermined, and flooding relieved the exterior pressure on the sheet piling, with the result that in a short time they began to break loose. Before the flood water had subsided, the river bed material surrounding this pier had scoured to bottom of the seal at the S.E. corner elevation 165. At the opposite corner the scouring carried down to elevation 129, only a few feet above the bottoms of the corner bearing piles. Scouring was unquestionably greatly increased due to the shape of the cofferdam itself, which was rectangular in form. It was provided by the plans and specifications to streamline the square ends of the concrete pier base as a part of its construction, but unfortunately the condition of the work at the time of the freshet had not reached this stage. Downstream from Pier 5 even deeper scour was found to have taken place, reaching elevation 122, about 75 ft. away. Although for a time it was feared that the work on Pier 5 would be destroyed, this did not happen, and actually no settlement took place.

Interesting observations were possible on the river currents during this exceptionally heavy freshet. During normal water, the current bears from south to north across the whole river, due to a heavy swing of the river to the southeast about one mile upstream, and to the existence of a broad sandbar at this bend in the river near the north bank. At the peak of the flood the sandbar was well covered and the current of the north half of the river was normal to the axis of the bridge, while although considerably straightened towards the south bank, still ran at an angle of about 10 degrees to the bridge axis. A heavy backwater was in evidence along the south bank. The depth of water at Pier 6, during the freshet, was reduced by 11 ft. The current in midstream reached a maximum velocity of eight and one-half miles per hour. Only the heavy upstream anchors held Pier 4 caisson from being pressed downstream. It was forced in that direction about two and one-half feet, of which one foot was recovered during subsequent sinking.

The problem of restoring No. 4 caisson was not difficult. The debris, consisting mainly of loosened forms, was removed. The caisson was partially righted for safety by jetting along the outside of the north portion of the cutting edge. Sinking operations were then continued, recovery of position taking place to the extent previously described. On completion of sinking, soundings indicated that the pier was sitting in a depression in the river bottom decreasing from 10 ft. alongside the caisson to nothing at a distance of 50 ft. This depression was back-filled with heavy sand and gravel, and rock riprap protection varying in thickness from 10 ft. alongside the caisson to three feet at the toe, was placed. The effect of this summer's freshet on the riprap protection will be checked and rock added if advisable. Figure 11 shows Piers 4 and 5 nearly completed.

The restoration plan for Pier 5 is shown in Fig. 12. The problem was primarily one embracing the following:

1. Restoration of bearing value of foundation piling.
2. Providing permanent protection against deep scouring action.
3. Streamlining the new work as far as practicable.

In the matter of restoring the bearing value of the pile foundation, particularly along the off-shore face of the pier, it was decided to backfill carefully around the exposed portions of the piles with suitable filling material. Pit run of sand and gravel, with 20 per cent excess of sand, was selected and placed carefully at first, to avoid side pressure on the piling. This filling was brought up to a level two feet below the bottom of the foundation slab and following this, fine sharp sand, selected to produce high frictional value, was jetted under the slab. Three exploration holes of four inch diameter were drilled on the centre line of the concrete slab longitudinally at the middle and quarter distances and by the use of sounding rods, the compacting of the supporting material was observable. Later, after steel sheet piling had been driven around the foundation, as shown in Fig. 12, additional jetting took place until the sand was forced well up the exploration holes.

Suitable filling material now having been deposited around the pier foundation, an outer steel sheet pile cofferdam consisting of Algoma Steel Company section B-6 —33 pounds per foot was driven at a distance of two and one-half feet from the sides of the concrete slab and with semi-circular ends, for stream line effect. The webs of the sheet piles were reversed in driving to give greater strength in cross bending and therefore provide greater resistance to unbalanced pressure of sand and gravel. The length of

**Fig. 11—Piers Nos. 4 and 5 Nearly Completed.**

sheet piling driven was 60 ft., the sections being driven by use of steam hammer and water-jet to a top elevation of 183, equivalent to eight feet below low tide level. This elevation also corresponds to the top of foundation slab which was finished at 183. Filling within the cofferdam was now carried up four feet to elevation 169. Wooden bearing piles were driven in the semi-circular ends to a top elevation of 171. Following this, four inch casing pipes, 44 in all, were placed at six foot centres in the end and side areas between cofferdam and foundation slab. Five feet of tremie concrete was now deposited between elevations 169 and 174 in the side and end sections, effectively sealing in the grouting casings.

Although it has not been indicated, it will be inferred that cement pressure grouting was being provided for. The object of this pressure grouting was two-fold, first to compact the sand and gravel foundation, and second to reduce interior pressure on the sheet piling in event of extreme scour from without. It will be noted that the sheet piling extended to elevation 123, the level of the bottom of the bearing piles. This, with protection now provided, appears to be sufficient for any contingency. Grouting operations were carried out by use of a pressure grouting machine and grout piping, the jet of which was driven down to average elevation of 153 before grouting. The operation was slow, as sand frequently blocked the jet, material was hard to penetrate with the jet points and freezing took place frequently. The average pressure used was 50 lb. per sq. in., as the jet could not be kept open with a lower pressure, which would have been desirable. In all, 4,000 sacks of cement were forced into the foundation material. Some escaped, as the bond between the sheet piling and the five foot concrete seal was frequently broken. The amount of grout forced into each location was governed by its appearance in adjoining casings and discontinued in any one location when this occurred. It was felt by the engineering staff that although the grouting operation did not result in entire consolidation, it had made a worth while contribution to the restoration plan.

In order to avoid undue disturbance of the water flowing around this pier, it was necessary to bring the level of the space between the sheet piling and the pier shaft up to base of shaft level, namely 183. This was accomplished by back filling with sand and gravel to a depth of seven feet on top of which two feet of coarse gravel, three inch to six inch, was placed. This finish appears to withstand any displacement by the current. Outside the cofferdam, over the sand and gravel filling which had previously been brought up to base of slab level, was now deposited rock riprap protection to an elevation four feet below the top of the steel sheet piling, namely to 179, placed carefully to a slope of one vertically to three horizontally.

A temporary crib cofferdam was employed to unwater the foundation slab for the purpose of constructing the pier shaft in the dry. This cofferdam was placed on top of the foundation slab, cement mortar grout being used to seal the contact between cofferdam and slab. The 10 by 10 in. cofferdam timbers were caulked between courses. No trouble was experienced in unwatering against the 14 ft. of head encountered.

### Contractor's Equipment

The contractor's equipment consisted of floating derricks, power scow, pump scow, floating pile drivers, floating concrete mixing plant, floating concrete hoist tower, tugs, scows, draglines, and light railway line and equipment.

Three floating derricks of 25, 30 and 35 tons capacity were available for handling lumber and timbers, excavation of foundations and similar work. Two of the derricks were equipped with compressors, and a two yard clam shell and a one and one-half yard orange peel bucket formed part of this equipment.

The power scow is a combined derrick and pump unit, having a 65 ft. boom, and capable of lifting 15 tons. Its hoisting engine is Lambert type 9 by 12 in., and the pumps are duplex reciprocating, one capable of supplying 700 gal. per min. at 125 ft. head, and the other 400 gal. at 125 ft. head. Auxiliary equipment is a 300 ft. per min. air compressor, and a one and one half kw. electric light generator. Steam is supplied by a locomotive type boiler and a donkey boiler. The power scow was used for water jetting, supplying air to the diver, and general purposes.

The pump scow is essentially a large capacity electrically driven pump mounted on a 43 by 120 ft. scow. The pumping unit is driven by a 650 hp. squirrel cage 2,200 volt induction motor and consists of two four-stage centrifugal pumps which can pump 3,800 gal. per min. at 400 ft. head. Four 10-ton derricks are located on the deck, for handling the hydraulic jacks, or other equipment. The power for this pumping unit is supplied by 500 ft. of three wire dredger submarine cable.

The floating driver was used for most of the pile driving on the river, the hammer being a 5,600 lb. drop hammer. It was also used for drilling and shooting the hardpan encountered at Pier 1.

The floating concrete mixer was designed and built for the particular needs of this job. It was built on a large scow 40 by 123 ft. and contains two one-yard Smith batch mixers capable of a maximum capacity of 80 cu. yd. per hr. when the concrete is mixed for one and one-half minutes per batch. The mixer was designed to be a compact flexible unit, easy handling and quick change from one mix to another. It contains 40 cu. yd. sand storage bunkers, 60 cu. yd. gravel storage bunkers, and cement storage of about 2,500 sacks. A conveyor belt carries the cement to the mixer room, and the sand and gravel are weighed in scales fed by gravity from the bunkers above. These scales are balanced to compensate for listing of the scow during weighing. Sand and gravel are fed to the bunkers by a two-yard clamshell bucket operated by a derrick on a 65 ft. boom. Power is supplied by two locomotive type and one donkey boilers and all equipment is steam operated. Driving and auxiliary equipment consists of two mixer engines, hoisting engines, pumps, a four and one half kw. generator, conveyor engine, etc.

The concrete after being mixed is dropped into a hopper and elevated by a hoist tower seventy feet high to a distributing hopper which feeds into a 50 ft. gravity spout.

Sand and gravel are taken from scows alongside, and continuous clamming is continued during pouring.

Cement is supplied from two storage scows, 102 by 32 ft. and the other 88 by 32 ft., with a total storage capacity of 1,500 sacks.

The floating concrete hoist tower was built on a 32 by 90 ft. scow with a 125 ft. tower. Its equipment consists of a donkey boiler, an American hoist engine 8¼ by 10 in. The concrete hoist bucket is fed from the mixer from a lower hopper and is elevated to an upper hopper discharging into a 35 ft. gravity shoot. A Chicago boom is fixed to the top of the tower for handling the shoot. This boom was also used for hoisting forms and reinforcing steel when the carpenters were erecting the forms. This tower was used principally to pour the concrete in the high river piers.

All of this floating equipment was towed and attended by three tug boats, one being a large steam tug, the *Fearful*, rated at 27.6 nominal hp. and 41.9 registered tonnage.

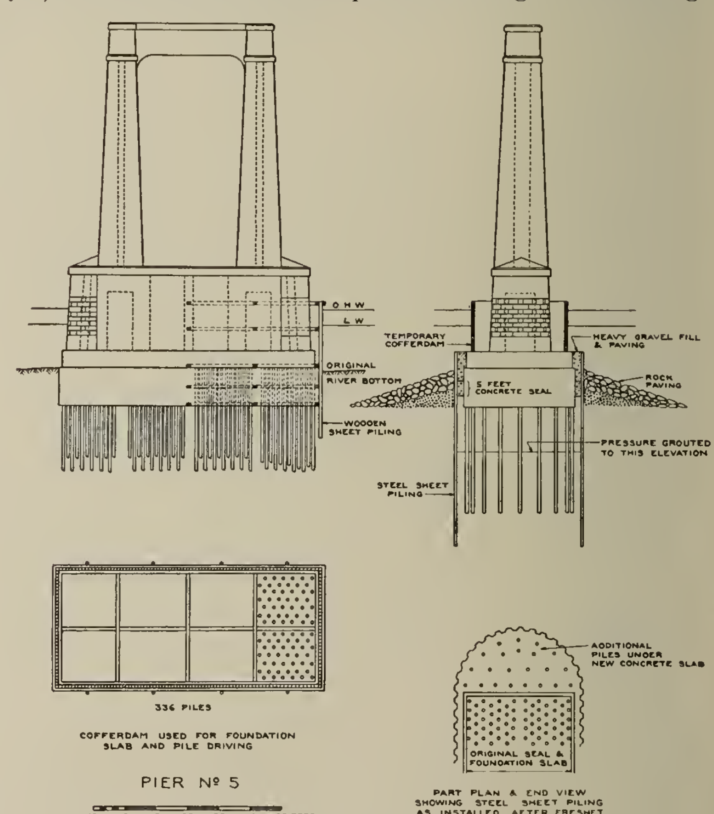


**Fig. 12—Pier No. 5, Showing Plan of Restoration.**

The other two, the *Harris* and the *Essangee*, are gas driven tugs 35 and 30 ft. in length respectively. The former is driven by a 45 hp. Buffalo engine and the latter by a 30 hp. Vivian engine.

In addition to the floating equipment described there are timber storage scows, sand and gravel scows, coal scow, a powder scow, and other miscellaneous scows.

Supplementary to the derrick equipment are two steam hammers used to drive timber and steel sheet piles and also some of the foundation piles driven under water;

also concrete and steel weights and anchors, buoys, divers' equipment, and 90 ft. of 12 in. tremie pipe.

Pumping of the caissons and cofferdams was accomplished by the pumps mentioned above and also several gas and electric pumps described below:—

1—200 hp. 2,200 volt electric centrifugal pump discharging 5,000 gal. per min. at 50 ft. head.
1—75 hp. 2,200 volt electric centrifugal pump discharging 3,000 gal. per min. at 50 ft. head.
2—20 hp. Ford gas 8 in. centrifugal pumps each discharging 1,500 gal. per min. at 50 ft. head.
1—125 hp. Waukesha 8 in. centrifugal pump discharging 2,000 gal. per min. at 50 ft. head.
1—20 hp. Jaegar 6 in. centrifugal pump discharging 1,000 gal. per min. at 100 ft. head.
2—6 hp. centrifugal pumps discharging 400 gal. per min. driven by a Sterling gas engine.

The land equipment consists of the items described below:—

A No. 14 Bucyrus dragline which was a five yard dragline converted to a 10-ten derrick. It has a 100 ft. steel boom and was used with a timber extension during part of the work making a total boom length of 120 ft. This machine weighs 90 tons and is steam driven. It is self propelled and the caterpillars occupy an area of 14 ft. by 27 ft. 6 in. It was used to hoist concrete and forms on the south viaduct.

A No. 20 B. Bucyrus shovel with a 45 hp. Atlas-Imperial Diesel engine was used on this job with a three quarter yard clamshell digging bucket, and was also used to hoist concrete and forms on the piers and viaduct on the south side of the river. The weight of this shovel is approximately 35 tons.

A speeder gasoline shovel which was a small shovel used early on the job for part of the pier excavations and for handling forms and hoisting concrete.

All pile driving on the land was done with a skid pile driver with 60 ft. leads. The hoisting engine was 8¼ by 10 in. A small air compressor capable of supplying 85 cu. ft. per min. was used for pneumatic drills.

Concrete was supplied to the south viaduct and piers on the south side from a narrow gauge track of about 2,000 ft. total length. Three gasoline driven locomotives 25 hp. weighing 6,000 lb. were used to haul the concrete and other materials. Nine one-cubic yard cone buckets on cars were used to deposit the concrete. These buckets discharged from a bottom ball valve operated from the Bucyrus.

The skid derrick on south concrete viaduct was a small stiff leg derrick operated by a 25 hp. Ford engine, and used to hoist forms on deck.

Water supply for the washing forms on the south side is supplied by a two-stage centrifugal pump operated by a 3 phase 220 volt 25 hp. motor; this motor feeds a 1,500 ft. water service pipe line.

In permitting this paper to be submitted, the courtesy is acknowledged of the Chief Engineer of the Provincial Public Works Department, Mr. Arthur Dixon, under whose direction and that of the Provincial Bridge Engineer, Mr. A. L. Carruthers, it has been a pleasure to serve, because of the spirit of efficient and friendly co-operation that has existed from the outset. The author begs to acknowledge also the excellent work and loyal support of his field staff under the direction of Mr. A. J. Leamy, who had served as assistant engineer on the construction of the original bridge in this location in 1902, and to his friend of many years, Major D. A. Graham, assistant resident engineer (now deceased,) and of his chief designing engineer, Mr. H. A. Rhodes. He is grateful also for the efficient work and fine co-operation of the officers of the contractor-in-chief, the Dominion Bridge Company, and of their sub-contractors, the Northern Construction Company and J. W. Stewart Limited.

The following engineering firms were employed by the author in a consulting capacity:—

Messrs. Monsarrat and Pratley of Montreal on the foundation work in the river.
Messrs. Sharp and Thompson, Consulting Architects, Vancouver.
Mr J Muirhead, Consulting Electrical Engineer, Vancouver.

# The Borden Bridge, Saskatchewan

*C. J. Mackenzie, M.C., M.C.E., M.E.I.C.,*
*and*
*B. A. Evans, M.Sc., A.M.E.I.C.*

## DISCUSSION[1]

J. F. Brett, A.M.E.I.C.[2]

The Borden bridge is the first concrete bow-string arch of over 200 ft. span built to date in Canada. As with concrete arches of all types, when the span exceeds some 150 ft., special attention must be paid to the stresses due to deformation or so-called parasitic stresses, which becomes the most important problem to be solved by the designer and the constructor as the span increases, in order to secure a rational and economical structure.

The authors are fully aware of the importance of this fact; the methods of design and construction they used have resulted in a structure which, in the writer's opinion, compares very favourably indeed with the best elsewhere.

In reading Part II, one cannot but feel that the authors have been very fortunate in being able to follow, during construction and after, by means of adequate observations, the coincidence of the theories on which their design is based and the actual behaviour of the structure.

We know that the shrinkage and other volume charges of concrete are closely related to the temperature and hydrometric state of the air, and since very little information on the matter concerning large monolithic structures under the peculiar conditions of Western Canada is available, the observations of elongation and deflection given in the paper are of great value to us.

The close agreement between computed and observed values is to the credit of the authors.

It may be said that the ideal conditions under which a concrete arch can act is the case where the work done results in the largest percentage of compressive stresses with the minimum amount of moments. For a given section and loads, the maximum fibre stress is lower, the more this principle is realized.

The authors have gone a considerable way towards this goal by using hinges for the arch and the tie, the provision

[1] Paper published in the Engineering Journal, May, 1937.
[2] Division Engineer, Montreal Water Board, Verdun, Que.

of roller bearing at one end and by the care taken of making the hangers as thin as possible in the longitudinal plane of the rib.

The girder approach spans resting on a compressible soil have also received careful attention, and are provided with split hinged columns and rocker bearing to provide for expansion and contraction and possible differential settlement. With these precautions it is possible and safe to construct continuous girder bridge spans on compressible soil foundations, a current practice abroad since many years, but which we are sometimes a bit timid in adopting.

The authors have been most candid in disclosing all their observations of the finished structure, pointing out where improvements should be attempted in the future under similar conditions. For this reason, the writer wishes to submit a few suggestions to those interested in this type of construction.

In the bridge under review, due to remote location, it was found quite expensive to weld the horizontal tie steel. The authors resorted to lapping after an experimental determination of the amount of concrete necessary to transfer the stress. If lapping is used, then the tie must be concreted first, which means that the tie concrete will be subjected to the full extension of the steel. If welding is out of the question, flat steel bars connected with turned bolts may be used; even if higher stresses occur at the connections, this would not affect the total elongation much.

It is also possible to pre-stress, so to speak, the tie steel; this will likely be the ultimate solution.

The only way to be absolutely sure to avoid small tension cracks in the tie concrete, if the latter is to bear the full elongation, would be to reduce the stress to somewhat about 13,000 lb. per sq. in.

The procedure of concreting the tie after the ribs also eliminates the possibility of the sag of the hangers. The latter may be put under some initial tension of letting them carry part of the weight of the tie bars. This results in a fairly uniform tension in the hangers which insures an even distribution of the deck load on the ribs at the time of decentring. If the tie is concreted first, the use of an I beam instead of bars as hangers is suggested. It is also possible to avoid hanger bars sagging by making them in two separate units to be welded together after the concreting of the ribs.

In connection with the hinges, the question arises as to where they may be located in the structure in order to obtain a maximum reduction of moment. The writer knows of a number of existing structures where the hinges were placed at the crown and at the junction of the terminal blocks with the ribs. The important point is to avoid any rotation of the terminal blocks so that a uniform pressure is exerted on the bearing seats. However, the authors have obtained a very satisfactory reduction of moment stresses with the lower hinges placed on the tie, a scheme which is new so far as the writer knows. This scheme deserves the close attention of designers since it permits the worthwhile saving of the extra reinforcing steel that would be required for a compression hinge located above the terminal blocks.

In connection with the bridge floor slab, the authors state that "one quarter of the negative moment steel was run through the top of the slab to care for tension which may be developed through the elastic extension of the tie." That the ties and the floor system work together as soon as the concrete hardens has been observed by several investigators including the present writer. Since the amount of extension that will occur depends largely upon the scheme of erection, hard and fast rules cannot be laid down. The writer believes that as a rule it is worth while to arrange the slab reinforcing with two separate layers of bars, top and bottom, the negative moment bars running the full length of structure.

The strain gauge readings taken at the crown hinge, together with the measurements of the tie elongation and the downward deflection of the rib during the decentring operations and in the early stages of loading, show the great difficulty of interpreting such data which represent the combined influence of rib shortening, tie elongation, temperature variation, the so-called plastic flow, etc. The interplay of these different factors is such that it may not be possible to assign definite value to any of them separately.

It is for this reason that the writer feels the method of pre-stressing can be applied to concrete bow string arches with great advantage. If the tie only is pre-stressed, it would be a very simple operation and could be carried out readily today without the necessity of much pioneering.

Using structural steel grade bars, the elastic limit of which has been raised by pre-stretching, a unit tensile stress of some 30,000 lb. per sq. in. or higher could be used with absolute safety since the elastic equilibrium of the structure as a whole is under control. Temporary hinges would not be required and the bow string would become a true two-hinged arch unaffected by tie elongation and deflection of the rib.

In reading Part III, one may appreciate the difficulties, due to extreme climatic conditions, faced by the authors and their associates during the construction of the substructure in the severe winter of 1935-1936. The fact that excellent workmanship was obtained in spite of it all is greatly to their credit.

In closing, the writer wishes to congratulate the authors in having created a splendid bridge, remarkable both for its technical excellence and for its artistic appearance.

E. M. Rensaa, A.M.E.I.C.[3]

The paper on the design and construction of the Borden bridge should be very welcome in that it deals with a subject about which comparatively little information is available in American technical literature. The authors are to be congratulated for the clear and detailed presentation, and especially for drawing attention to details which might be improved upon in future bridge construction.

The delay in elongation of the tie was probably due to continuing sliding of the tie bars as the tension in the steel increased and the bond resistance was overcome. This sliding would start at the cracks in the concrete and progress toward the middle of the 18 in. sections into which the tie concrete had cracked. The strength of the bond although probably somewhat impaired by the sliding would not reach a zero value and the concrete between the cracks would consequently still carry some tension with a corresponding reduction in the theoretical value of the elongation. The delay in the elongation would thus have little to do with plastic flow, especially since the effect of this would be counteracted by shrinkage.

It would be interesting to know what allowance, if any, was made for the tensile stress in the roadway, which could not be avoided with the method of construction used. It should be clear that the combined stress in the slab would be very different and less favourable than for the case of bending only. The shrinkage would add further to the tension in the concrete, and cracking of the slab under this condition could hardly have been prevented by the addition of some more reinforcement on the upper side. Besides the effect of cracking in weakening the slab against bending, it is also a question if the roadway will prove to be durable without the use of waterproof protection.

The problem of eliminating the tensile stress in the roadway cheaply and effectively has received much attention in Europe where reinforced concrete bow-string arch bridges have been much more frequently built than in

[3] Bonde and Company, Consulting Engineers, Oslo, Norway.

America. Several methods have been proposed and used which will either decrease or entirely remove this unwanted stress. It may be said in general that the tie should be the last member to be concreted, in order that it may be left free to elongate. As much dead load as possible should also be carried by the arch system before the tie and roadway are connected. The arches should therefore be built first in connection with steel ties which will allow that part of the structure to be released before the roadway is completed. The roadway may then be constructed by means of falsework suspended from the arches, and as the last operation the tie sections may be completed. It will also be beneficial to load the middle of the roadway in order to make up for the weight of the tie concrete before the connection is made by the last operation, and this load may then be removed as the concrete is placed.

The well-known German engineer Dr. Dischinger has proposed another method to achieve the elimination of roadway tension. The tie is placed in an open U-channel in the tie concrete, and hydraulic jacks introduced between the end of the tie and the terminal end of the arch. The tie may then be shortened by means of the jacks and as much compression as is desired introduced into the roadway, after which the tie is fixed to the arch and the channel concreted. Another advantage obtainable by this method is that the temporary crown hinge may be left out, as the bending stress introduced into the arch by axial deformation may be removed by shortening the span by means of the hydraulic jacks.

One reason why the tensile stress in short span bowstring arches has not caused more trouble is that the steel in the roadway which generally is not counted on as aiding the ties, will be such a large percentage of the total that the true average stress will be low enough to prevent serious cracking.

The temporary crown hinges seem to have worked satisfactorily, but it is the writer's opinion that higher working stresses might safely have been used for the 5,000 lb. concrete. It is essential that the stress in the hinge should be near the ultimate for unspiralled concrete as it is only under such condition that the concrete will be plastic enough for centring the thrust. The bending stress in the hinge calculated for that condition will, of course, be quite misleading. W. L. Scott, chief engineer, the Considère Construction Co., in England, stated in his book on concrete bridges that stresses in excess of the ordinary ultimate have been used successfully in Europe. He recommends as much as 8 per cent spiral steel in order to allow high stress and also says that it is not necessary to cut the arch reinforcement as the concrete core will shorten enough to prevent tensile stresses in the reinforcement. The steel is, of course, to be left uncovered for a sufficient length so that the part in compression will buckle. The angular movement in the hinge of a bow-string arch will of course be greater than for arches with immovable abutments and it is quite possible that cutting the steel was the safest in this case.

The authors' findings that no appreciable moments were induced into the arch ribs near the abutments due to deflection confirm an opinion earlier expressed by the writer. It would seem evident that the tie cannot have much restraining effect since it must deflect to about the same curve as the arch, neglecting the almost negligible effect of hanger elongation. The introduction of structural steel hinges at the junctions between the arch and the tie, as was done on an American bridge, would therefore seem to be an expensive and unnecessary detail, which really is apt to weaken the structure.

Perhaps the best method to avoid construction difficulty with the hangers would be to make each out of a single heavy bar, as is quite often done in Europe, and to leave out the concrete covering which in this case cannot be good for much else than rust protection. If the true cost of that concrete is counted including the excess steel required for the ties, it would probably be found that the hangers might have been much more cheaply protected by other means. The steel fence has to be painted now and then in any case, and it would not add much to the cost to maintain the hangers at the same time.

Whether or not the long span reinforced concrete bow-string arch bridge will be more frequently built in the future, will depend on its economic feasibility compared with steel spans. Its superior aesthetic value seems unquestionable, but its durability will depend to a large degree on careful construction. A more economical structure than the ordinary bow-string arch with vertical hangers is the arch with inclined hangers as invented by the Danish engineer Dr. O. F. Nielsen. This arch system combines the advantages of both the arch and the truss in that bending stresses are almost negligible. The great economic superiority of this structure both over the steel truss and the ordinary through reinforced concrete bow-string arch bridge for highway loadings and spans around 200 ft., has been confirmed by some investigations recently made by the writer.

P. B. Motley, M.E.I.C.[4]

Apparently the curves of the bows of the arches were of circular section. Why had they not been made parabolic?

C. R. Young, M.E.I.C.[5]

It would be helpful to know the circumstances that led the authors to use the Considère rather than the Mesnager type of hinge for the crown of the arch ribs. Considerable experimental data exist respecting the behaviour of the latter hinges, thanks to the researches of Mesnager himself and those of Parsons and Stang of the National Bureau of Standards, Washington. It might appear that some uncertainty of behaviour would have been avoided by using the Mesnager type with close transverse spacing of the converging rods.

The placing of a richer mix of concrete in the pier noses than in the adjacent portions suggests the inquiry as to whether any shrinkage cracks developed at or near the boundary of the differing mixes. Such cracks have been known to develop in other work to an extent indicating the need of special reinforcement in the region.

Forecasting of probable temperatures of mass concrete placed in cold weather is admittedly difficult, but it would be interesting to know if the authors could suggest any rough empirical rule for the resultant temperature at the side surfaces based on volume of the mass, form thickness and air temperature.

W. T. B. McCormack[6]

In moving a vote of thanks to the authors, comment should be made on the difficulties of pouring concrete during a Canadian winter. He had put in the concrete for a bridge at a temperature of 100 deg. F. Sometimes better work was done with inexperienced men, than with more experienced forces.

C. J. Mackenzie, M.C., M.C.E., M.E.I.C.[7] and
B. A. Evans, M.Sc., A.M.E.I.C.[8]

The authors appreciate very much the many complimentary remarks, criticisms and suggestions which have been expressed by those taking part in the discussion,

[4] Engineer of Bridges, Canadian Pacific Railways.
[5] Professor of Civil Engineering, University of Toronto.
[6] Chairman of the County Roads Board of Victoria, Australia.
[7] Dean of Engineering, University of Saskatchewan, Saskatoon, Sask.
[8] Designing Engineer, Borden Bridge, Saskatchewan.

particularly as all of the contributors have had extensive experience in this general field.

Both Messrs. Brett and Rensaa have drawn attention to very important considerations in connection with the design of the horizontal tie, which is a crucial feature of bow-string arches. A great deal of study was given to this aspect and designs were first prepared using flat eye-bars, and much consideration was given to welding, but, while both of these methods would have permitted the concrete envelope to be placed after the steel had elongated elastically, the former was ruled out due to excessive costs and difficulty of making the end connections, while the latter, as was stated, did not seem wise or economical under the existing conditions of remote location and doubtful availability of experienced and reliable welders. The discussion, therefore, must be considered in the light of the method adopted, although the authors would have preferred the welding of tension bars.

With regard to pre-stressing of the horizontal ties, there is the theoretical advantage that bending moments in the arch ring, due to elastic elongation of the tie may be thus practically eliminated and, as suggested by Mr. Rensaa, the necessity for a temporary crown hinge on that score avoided. In the particular case under consideration, however, where the piers did not have sufficient lateral stability to take up the necessary horizontal force of 2,000,000 lb. this method was not practicable. Even in the ideal case where pre-stressing would be feasible it is doubtful whether it would be advisable to go to the expense of pre-stressing in order to eliminate the crown hinge, which is much simpler and cheaper to construct and which in addition reduces potential bending moments due to factors other than elastic elongation of the tie.

There is little doubt that, if concreting of the tie could be left until the end, it would be a decided advantage; the cracks, which, incidentally, are very small and barely noticeable, would have been entirely eliminated, as the live load stresses and elongations are almost negligible as compared with the dead load effects, but what is more important the construction of the hangers would have been facilitated. The authors are inclined to agree with Mr. Rensaa that the vertical hangers, on economic and aesthetic grounds, might very well be made of an unprotected steel section.

The design of the floor system and its action under tie extension is another interesting feature referred to by both Messrs. Brett and Rensaa. In the design under consideration no allowance was made for any action of the floor system as a horizontal tie. If the pouring of the floor slab can be delayed until the horizontal tie has assumed its full elongation, due to arch ring, horizontal tie and floor beam dead weights, the extra elongation due to floor slab dead weight and live load would not introduce much longitudinal stress in the floor slab steel, and few cracks in the slab would appear. The suggestion that, instead of using the existing falsework, the floor system forms be suspended from the arches would, in our opinion, be quite expensive and the advantages of minor importance. The suggestions that more longitudinal steel be used in the floor system appears to be more practical.

There is little doubt, as laboratory tests carried out by the authors and many others have proved, that in the temporary hinges unit stresses well above the normal ultimate concrete strength could have been used, but there is little experimental data published on the increased flexibility that would have been obtained. When it is considered that nearly ninety per cent of the potential moment in the arch ring was relieved and that, if perfect articulation had been obtained, the actual stresses in the arch could not possibly have been relieved by more than twenty pounds per square inch, one may question whether, if very high hinge stresses were used in order to take advantage of a rather indefinite increase in flexibility, the loss in safety factor against unanticipated occurrences would not be too large a price to pay for a comparatively slight decrease in arch ring stresses.

Mr. Rensaa raises a pertinent point when he states that the future use of concrete bridges of long span will depend on their relative cost as compared with steel. It might be interesting to note that the superstructure on the Borden bridge cost no more than a steel span of similar span in a neighbouring location and, in the authors' opinion, where foundation conditions are good, long span concrete arches are competitive in cost with steel in Canada.

A design, after Dr. O. F. Neilsen's plan of inclined hangers for a bow-string, would be interesting. The only design of this type studied by the author was for a span where the major portion of the direct arch thrust was taken up by the abutments.

In reply to Mr. Motley, we would say that the axis of the arch was made to follow roughly the dead load string polygon and is more nearly parabolic than circular.

Professor Young very aptly inquires why, for the arch crown hinges, the Mesnager type, which has been subject to much study, was not used instead of the Considère type, for which there is less experimental data. The Mesnager type was preferred but it was found that the dimension of the arch ring indicated on other grounds did not provide a ring of sufficient width to use that type of hinge.

With regard to the method of strengthening the concrete in the pier noses, this was done by sprinkling dry cement over the concrete deposited at that location and tamping thoroughly; in this way there was no definite boundary between the mixes and no development of cracks.

The problem of forecasting probable temperatures of mass concrete placed in cold weather is, as Professor Young suggests, difficult and, while the authors have been interested in this problem for some time, they feel that, considering the number and uncertainty of the factors involved, any empirical rule might be more dangerous than helpful. It has been our practice to make liberal use of inexpensive resistance thermometers, as described in the paper, to follow concrete temperatures daily or hourly under severe temperature conditions, and then to provide temporary protection or heat if and where needed.

It was a novel and pleasant experience to have the vote of thanks tendered so sincerely by Mr. W. T. B. McCormack, a native of our sister Dominion of Australia, who contrasted in an interesting manner the effects of opposite temperature extremes which have to be met in our two countries, located as they are at opposite ends of a terrestrial diameter.

# A Study of Standard and Increment Methods of Measuring Stream Flow

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**Paper presented at the Semicentennial Meeting of The Engineering Institute of Canada, in Montreal, June 16th, 1937.**

SUMMARY.—Compares two ways of developing a rating curve for the Bow river, Alberta, viz.:—The standard current-meter system and a new method based on known discharges through the power plant corresponding to certain increments of load.

In Alberta as in other provinces of Canada, stream flow studies are conducted by the Dominion Water and Power Bureau, Surveys and Engineering Branch, Department of Mines and Resources. These studies are carried on in co-operation with the provincial governments, and other private corporations or departments who have special problems relating to surface run-off, usually pertaining to a certain area.

The importance of an adequate supply of surface water cannot be over emphasized and it usually requires a water shortage to bring home the truth of this statement. The present drought conditions in western Canada have given abundant evidence of the value of surface water, and have proved that water is a resource of first importance.

Water is basic to the development and utilization of other resources such as mines, forests and lands, as well as to navigation, irrigation, water power and industry in general. The distribution of surface water, usually by stream flow, but by whatever means, therefore, becomes a very important matter. The accumulation of long-term records of stream-flow measurement data is the method adopted by the Dominion Government in analyzing the surface run-off for various streams throughout the country. Water Supply Papers issued annually contain this information and in Alberta, the flow data for a number of the important streams have been continuous for nearly thirty years. Experience has indicated that these stream flow records constitute the most reliable information of the water supply available from any drainage basin.

In the case of the Bow river in Alberta, the twenty-five years of these records show a great variability from year to year and from season to season. A flood stage for a short period may be over one hundred times greater than the minimum winter flow. Also, averages of the years or averages of the winter flow periods are not necessarily good guides to the probable water supply for the present year or for the next low water season. From a power viewpoint the dates of beginning and end of each low water season are subject to large and unpredictable variations. An early cold winter and late spring may necessitate many thousands of acre feet of storage water for power purposes more than would be indicated by forecasts based on the averages of past records.

A prolonged period of less than normal rainfall in the catchment basin results in a lower ground water table and less run-off may be expected during the next winter period. However, such general indications must always be supported by accurate records of stream flow, and the great variation in amount of run-off from year to year emphasizes the importance of daily records.

In many cases the average daily discharge can be obtained during the winter period by a hydro plant located on the river and in summer at a standard gauging station below the plant. The gauge height discharge relationship at a standard gauging station so located may be determined by current meter measurements or by use of the "increment method." Both of these methods will be described.

The study under consideration in this paper has only to do with the particular flow of the Bow river near Radnor. It has been made possible through the co-operative efforts of the engineers of the Calgary Power Company Limited and the engineers of the Dominion Water and Power Bureau, in the joint maintenance of this gauging station.

In the matter of the determination of the discharge of any surface water stream, several methods may be employed. As early as 1775 the famous French formula $V = C\sqrt{RS}$ was developed by the French engineer M. Chezy, and this formula has been very widely used even to the present day. Where stream stages are very high and velocity flow instruments cannot be lowered into the water due to floating debris, ice, etc., the Chezy formula is still commonly used. Where the stream flow is very small and suited to the installation of a weir, this method is preferable and often used. In general practice, however, in Alberta, stream flow measurements are made by the use of a current meter. During the history of the hydrometric survey in Alberta, as well as for all of Canada, various types of current meters have been used and extensive experiments have been conducted at the Dominion Government Rating Station at Calgary on different types of meters with a view to selecting from time to time the most suitable instrument for the work at hand.

TABLE I*

DOMINION WATER AND POWER BUREAU

Discharge Table for Bow River below Ghost Plant near Radnor, Alberta. Developed by the Dominion Water and Power Bureau by the standard method.

| Gauge height Feet | Discharge Sec.-ft. | Difference Sec.-ft. | Gauge height Feet | Discharge Sec.-ft. | Difference Sec.-ft. | Gauge height Feet | Discharge Sec.-ft. | Difference Sec.-ft. |
|---|---|---|---|---|---|---|---|---|
| 0.00 | 362 | 158 | 2.00 | 4,510 | 270 | 4.00 | 11,300 | 400 |
| .10 | 520 | 159 | .10 | 4,780 | 280 | .10 | 11,700 | 400 |
| .20 | 679 | 160 | .20 | 5,060 | 280 | .20 | 12,100 | 410 |
| .30 | 839 | 161 | .30 | 5,340 | 290 | .30 | 12,510 | 410 |
| .40 | 1,000 | 180 | .40 | 5,630 | 300 | .40 | 12,920 | 410 |
| .50 | 1,180 | 180 | .50 | 5,930 | 310 | .50 | 13,330 | 410 |
| .60 | 1,360 | 190 | .60 | 6,240 | 320 | .60 | 13,740 | 410 |
| .70 | 1,550 | 190 | .70 | 6,560 | 320 | .70 | 14,150 | 410 |
| .80 | 1,740 | 200 | .80 | 6,880 | 330 | .80 | 14,560 | 420 |
| .90 | 1,940 | 200 | .90 | 7,210 | 340 | .90 | 14,980 | 420 |
| 1.00 | 2,140 | 210 | 3.00 | 7,550 | 350 | 5.00 | 15,400 | 420 |
| .10 | 2,350 | 220 | .10 | 7,900 | 360 | .10 | 15,820 | 430 |
| .20 | 2,570 | 220 | .20 | 8,260 | 370 | .20 | 16,250 | 440 |
| .30 | 2,790 | 230 | .30 | 8,630 | 370 | .30 | 16,690 | 440 |
| .40 | 3,020 | 240 | .40 | 9,000 | 380 | .40 | 17,130 | 450 |
| .50 | 3,260 | 240 | .50 | 9,380 | 380 | .50 | 17,580 | 450 |
| .60 | 3,500 | 240 | .60 | 9,760 | 380 | .60 | 18,030 | 450 |
| .70 | 3,740 | 250 | .70 | 10,140 | 380 | .70 | 18,480 | 450 |
| .80 | 3,990 | 260 | .80 | 10,520 | 390 | .80 | 18,930 | 450 |
| .90 | 4,250 | 260 | .90 | 10,910 | 390 | .90 | 19,380 | 450 |
| | | | | | | 6.00 | 19,830 | 450 |
| | | | | | | .10 | 20,280 | |

*The above table is not applicable for ice conditions. It is based on 20 discharge measurements made during 1933, 1934, 1935 and 1936.

Table II

Discharge Table for Bow River below Ghost Plant. Developed by Increment Method by Ghost Hydroelectric Plant, Calgary Power Company, from April 1936 to Ice 1936.

| Gauge height Feet | Dis-charge Sec.-ft. | Differ-ence Sec.-ft. | Gauge height Feet | Dis-charge Sec.-ft. | Differ-ence Sec.-ft. | Gauge height Feet | Dis-charge Sec.-ft. | Differ-ence Sec.-ft. |
|---|---|---|---|---|---|---|---|---|
| 0.00 | | | 2.00 | 4,330 | 300 | 4.00 | 11,210 | 390 |
| .10 | 576 | 99 | .10 | 4,630 | 310 | .10 | 11,600 | 400 |
| .20 | 675 | 105 | .20 | 4,940 | 320 | .20 | 12,000 | 410 |
| .30 | 780 | 140 | .30 | 5,260 | 330 | .30 | 12,410 | 420 |
| .40 | 920 | 140 | .40 | 5,590 | 340 | .40 | 12,830 | 430 |
| .50 | 1,060 | 160 | .50 | 5,930 | 340 | .50 | 13,260 | 430 |
| .60 | 1,220 | 180 | .60 | 6,270 | 340 | .60 | 13,690 | 430 |
| .70 | 1,400 | 190 | .70 | 6,610 | 340 | .70 | 14,120 | 430 |
| .80 | 1,590 | 200 | .80 | 6,950 | 340 | .80 | 14,550 | 430 |
| .90 | 1,790 | 200 | .90 | 7,290 | 350 | .90 | 14,980 | 430 |
| 1.00 | 1,990 | 200 | 3.00 | 7,640 | 350 | 5.00 | 15,410 | 430 |
| .10 | 2,190 | 210 | .10 | 7,990 | 350 | .10 | 15,840 | 440 |
| .20 | 2,400 | 210 | .20 | 8,340 | 350 | .20 | 16,280 | 450 |
| .30 | 2,610 | 210 | .30 | 8,690 | 350 | .30 | 16,730 | 450 |
| .40 | 2,820 | 220 | .40 | 9,040 | 350 | .40 | 17,180 | 450 |
| .50 | 3,040 | 230 | .50 | 9,390 | 350 | .50 | 17,630 | 460 |
| .60 | 3,270 | 250 | .60 | 9,740 | 360 | .60 | 18,090 | 480 |
| .70 | 3,520 | 260 | .70 | 10,100 | 360 | .70 | 18,570 | 510 |
| .80 | 3,780 | 270 | .80 | 10,460 | 370 | .80 | 19,080 | 540 |
| .90 | 4,050 | 280 | .90 | 10,830 | 380 | .90 | 19,620 | |

In water power operations various methods or combination of methods may be selected for determining the total stream flow past the plant and the Calgary Power Company has developed a new method which was used to rate the Bow river below their Ghost plant some 32 miles west of Calgary. The Ghost hydro-electric plant has a head of 110 ft. and an initial installation consisting of two vertical units of 18,000 hp. each with one station service unit of 1,450 hp. These units have been rated by the Gibson method and careful records are kept by the plant operators of the amount of water used by the plant each hour.

In conjunction with these measuring facilities at the power plant, the Dominion Water and Power Bureau maintains a gauging station about three miles below the plant. At this point an automatic gauge, housed in a shelter, provides continuous water stage records, and at

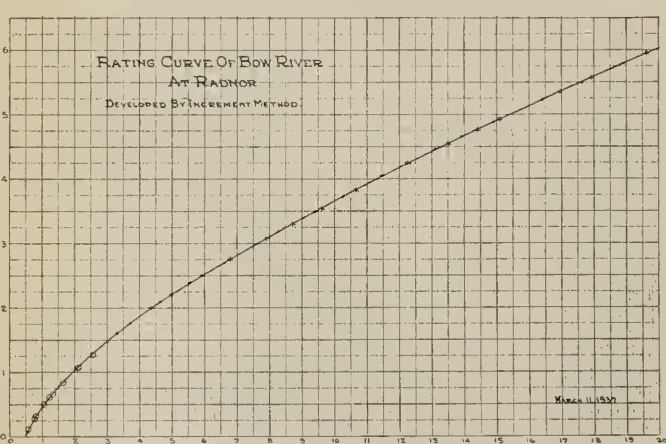


**Fig. 1—Rating Curve of Bow River Developed by Increment Method.**

a point about one mile below the plant, a cable is erected over the river from which current meter discharge measurements are secured.

All measurements at the above gauging station have been made with the standard equipment of the Dominion Water and Power Bureau including cable car, current meter, timing apparatus, sounding board, elliptical sounding weights, etc. The current meter and weights were suspended by 18 strand 1/16 in. diameter steel cable with a water return recording apparatus. Velocities in the vertical for each measurement were taken at 10-ft. intervals over a river width varying from 163 ft. at low water to 295 ft. at high water. The measurement experiments as conducted covered stages up to moderately high water comprising maximum sounding depths of 12.5 ft. Mean velocities for discharge measurements varied from 2.28 ft. per sec. at low water to 8.56 ft. per sec. at high water. Twenty current meter measurements in all have been secured and while the measuring section is not a perfect one, especially at low stages, owing to parts of the river bed being rough, yet the curve has been fairly well defined for all stages.

The use of the power plant for determining the daily winter flow of the river has many advantages. This method is free from the possible large inaccuracies in backwater estimates which comprise the major difficulty at gauging stations under varying ice conditions. However, during the open high water period the flow through the plant is small in relation to the total discharge of the river and the gauging station below the plant is necessary at this time.

The "increment method" used by the Calgary Power Company in developing the gauge height discharge curve at this gauging station, was to release known amounts of water by means of the Ghost power plant and to add this to the sluice dam discharge which was determined from the portion of rating curve already established.

The first step was to form the lower portion of the rating curve. This was done by the power plant alone from the lowest flow to high discharges which could be passed through the machines at times when no water was being spilled through the sluices. In order to do this a base load was carried by one or two machines at the Ghost plant to discharge a definite amount of water and this load was held until the graphic record of gauge height at the gauging station indicated a constant flow for at least one hour. The gauge height corresponding to this flow was read from the graph and the discharge was computed from the plant records. In this manner the rating curve was developed from 160 to 2,550 cu. ft. per sec.

The next step was to transfer all load from the Ghost plant to the other plants in the system and to operate the sluice dam to give a river flow at the gauging station somewhat less than the 2,550 cu. ft. per sec. previously determined. When the graphic record of gauge height indicated a constant flow, the sluice discharge was found to be 2,100 cu. ft. per sec. This was read from the portion

Table III

Percentage Difference between the two tables at half foot intervals of change in stage. Above two feet it will be noted that the results are remarkably close.

| Gauge height in feet | Dominion Water and Power Bureau Table used as Basis Table Sec.-ft. | Calgary Power Company Increment Table Sec.-ft. | Difference Sec.-ft. | Per cent difference |
|---|---|---|---|---|
| 0.5 | 1,180 | 1,060 | −120 | −10.2 |
| 1.0 | 2,140 | 1,990 | −150 | − 7.0 |
| 1.5 | 3,260 | 3,040 | −220 | − 6.7 |
| 2.0 | 4,510 | 4,330 | −180 | − 4.0 |
| 2.5 | 5,930 | 5,930 | 0 | 0.0 |
| 3.0 | 7,550 | 7,640 | + 90 | + 1.2 |
| 3.5 | 9,380 | 9,390 | + 10 | + 0.1 |
| 4.0 | 11,300 | 11,210 | − 90 | − 0.8 |
| 4.5 | 13,330 | 13,260 | − 70 | − 0.5 |
| 5.0 | 15,400 | 15,410 | + 10 | + 0.1 |
| 5.5 | 17,580 | 17,630 | + 50 | + 0.3 |
| 6.0 | 19,830 | | | |

of the rating curve which had been completed. The flow of 2,100 cu. ft. per sec. was maintained through the sluices and the plant then picked up enough load to give an additional discharge of 1,200 cu. ft. per sec. The total flow would then be 3,300 cu. ft. per sec. for which a gauge height would be recorded at the gauging station. This gave a new point for extension of the rating curve.

The plant was closed off again and the sluice discharge increased to 3,020 cu. ft. per sec. as shown by the rating

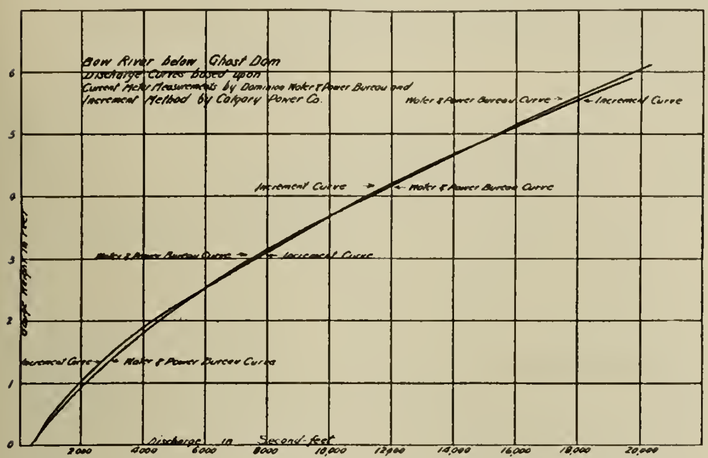


**Fig. 2—Current Meter Measurements of Bow River by (*a*) Dominion Water and Power Bureau and (*b*) Increment Method.**

curve. This flow was maintained at the sluices and the plant added another 1,340 cu. ft. per sec. which gave a total of 4,360 cu. ft. per sec. and another new point for extension of the rating curve.

In this manner the increasing spring flow was utilized to rate the river up to 20,000 cu. ft. per sec. by spilling through the sluices an amount which could be determined from the rating curve already established and adding a known amount through the power plant to give a further extension to the curve. A large number of check tests were made whenever river flow and load conditions were suitable and the manner in which these confirmed the original data indicated that confidence could be placed in the final result.

A brief description of the set-up necessary to follow this method may be of interest.

It is necessary to have an accurate means of determining the amount of water used each hour by a hydro plant and the fundamental information for this is obtained from recent overall ratings of each unit in the plant. Tables can then be compiled from these ratings to show the relation of kilowatt output to the water used for each machine under all conditions of head and load.

The Calgary Power Company's method of using this information was to select the greatest kilowatt output per second-foot which could be generated by the most efficient machine in the plant at its best load at full supply head. This was considered the maximum output for which there was no loss due to head or to unfavourable load apportionment. The output per cubic foot per second of water of this most efficient unit at any other load, or at less than full head, was of course less than the greatest possible output by a definite amount which could be expressed in kilowatts loss. Similarly all other units for the various loads and heads were compared to this highest possible output in kilowatts per cubic foot per second and their loss amounts listed in kilowatts below this amount. In this manner the ratings of all the machines were tabulated, showing a kilowatt loss amount below the maximum possible output of the most efficient machine in the plant. To determine the water used by any machine under the actual conditions of load and head the operator reads the kilowatt loss corresponding to the load and head conditions for each machine at the time, to which is added the load generated. This total kilowatt amount, when divided by the maximum kilowatts per second foot possible with the most efficient machine, will show the water used by the unit for the period. By this method the amount of water used by each machine is known and the total discharge below the plant, including leakage, may be determined.

This information served a double function, since it not only allowed a rapid determination of the amount of water used by each machine under any condition of load and head, but it also formed the basis of a plan for selecting the best combinations of machines and indicated the most efficient load for each machine for any required total load on the plant.

All leakage, including sluice dams, flashboards, headgates, turbine gates and other known percolation, is included in the total discharge recorded for the flow past the plant each hour. This provided the method of adding known increments of water by the power plant to determine the rating curve at the gauging station below the plant.

During the rating of the river discharge at the gauging station, the amounts of water spilled through the sluice dam were known, since the discharge was always held within the developed portion of the rating curve. The increment added by the plant to this gave the new point each time for the extension of the rating curve when used with the corresponding gauge heights shown at the gauging station. However, it was difficult to hold the sluice dam discharge constant which was a desirable condition for this method. The reservoir above the dam was always in a rising or falling stage during these operations and it was found necessary to rate the sluice openings in order to compensate for these changes in head. There are many variables and difficulties which arise in the rating of sluice dams when the openings are considered as broad crested weirs, and all test runs which showed a rise or fall of the reservoir exceeding one-tenth of a foot were discarded and corrections were computed for the minor changes in head. It was found that any single sluice opening, operated alone, could be rated quite accurately as a broad crested weir for the varying conditions of head and the height of stop logs in the opening. Also, the entire sluice dam could be rated satisfactorily with all stop logs removed from all of the openings, but difficulty was found in rating two or three adjacent openings together, as the ratings were never consistent with the sum of the individual discharges of the sluices. This is probably due to a combination of velocity of approach conditions above the sluices and the varying partial vacuum conditions below the crest. Spilling at the sluice dam during the tests, for the purpose of rating the gauging station, was carefully controlled and the required discharge obtained by operating single sluice openings with at least two closed openings on either side. The high amounts of sluice discharge were obtained when all stop logs were removed from all of the openings.

Figure 1 indicates the development of the rating curve derived by the "increment method." The circles represent discharges obtained from the plant alone, the dots show discharges through the sluice dam which were determined from the gauge heights shown at the gauging station and the crosses indicate the sum of the sluice dam discharge and the increment passed by the hydro plant. The crosses show the new points used for the projection of this rating curve. It will be noted from this method that sluice discharges should always show a lesser gauge height than the highest point determined at the time on the rating curve, since otherwise the projection of the curve would be dependent upon an estimate of slope and subject to possible inaccuracies which would influence the location of the balance of the rating curve.

The Calgary Power Company rates this station by the "increment method" each spring and takes many test points in the fall so that slight changes in the control below the gauging station or formation of gravel bars here will be compensated for by comparable changes in the rating curve.

The rating curve for this gauging station determined by the Dominion Water and Power Bureau by their standard practice is remarkably close to that developed by the "increment method" and it is believed that this latter method may be used to advantage in many locations where stream flow records are required and where such hydrometric records are not ordinarily taken by the Dominion Water and Power Bureau or other departments.

# Freight Hauling in Undeveloped Territories of Canada

*J. B. D'Aeth, M.E.I.C.*

## DISCUSSION[1]

C. R. Townsend, A.M.E.I.C.[2]

The author stresses the part that organization plays in any successful transportation scheme in undeveloped territory and we agree, and believe it is true of all transportation. The first census of the trucking industry in the United States reveals a great concentration of business in the hands of a few truckers. In 1935, 1.5 per cent of all concerns operating there received nearly half the total revenue, operated nearly 30 per cent of all trucks, and paid over 53 per cent of the total payroll of the industry. It seems likely that there is a connection between being able to pay close attention to details of organization and the concentration of the trucking business.

It is proposed to discuss a single but important phase of winter transportation in an undeveloped country where sleighs are used. During a study of the use of motor trucks in winter sleigh hauls it was found that there is often a considerable difference in truck performance under apparently similar conditions and this was so marked that it was considered worth while to attempt the determination of coefficients of sliding resistance of steel runners on ice and snow roads.

The only careful consideration of the use of runners on ice and snow surfaces which could be found is contained in Bulletin 13 of the School of Forestry, Yale University, and this was written before trucks had been used on sleigh hauls. The bulletin shows the sliding resistance of logging sleds on an iced road as being from 20 to 45 lb. per ton of gross load and says that "The sliding resistance during very cold weather (−30 deg. to −40 deg. F.) is about 20 per cent greater on an iced road and about 30 per cent greater on a snow road than when the temperature is just below the freezing point."

It is a generally accepted theory that steel shod runners slide easily on an ice surface because the pressure of the runners on the ice causes a film of water to form which lubricates the ice surface. This is an excellent theory but it does not explain fully variation in the coefficient of resistance or the action of the runners.

Tests were made with model sleds and due to lack of time and of cold weather they were comparatively few in number and results are shown to indicate a trend rather than to be all conclusive. The apparatus used was simple, consisting of a wooden frame work, erected on the frozen surface of a lake, with a pulley suspended near the top and another pulley attached near the base. A rope, attached to the sled under test, was passed through the two pulleys on the frame work and had a tray suspended from the end. The tray supported weights which gave a measure of the force necessary to move the sled under test. At below freezing temperatures it was found that when sufficient weight was put on the tray to start the load, this weight almost immediately gave the sled a considerable acceleration. It was then decided to get two values, one for a force which would not quite move the sled and a second for a force which would keep the sled moving after it had been given an initial low velocity. It should perhaps be stated that care was taken to have the runners dry for each test and in determining the first value the sled runners were tapped continuously while weights were being placed on the pan so that there was no "freezing down."

The results of the test were plotted on a graph (Fig. 1), with weight in pan divided by gross weight of sled, against temperature. Two points were plotted at each temperature below freezing at which tests were made. One point for zero velocity and the second for a velocity of 2 to 3 m.p.h. At above freezing temperature no difference between zero velocity and extremely low velocities could be found as with the apparatus used no practical way of closely determining velocity was available.

Results for 2 to 3 m.p.h. sliding resistance at below freezing temperatures showed agreement with the figures given in the bulletin previously referred to, but the resistance at zero velocity was about twice as high at a temperature just below freezing and about three times as high at a temperature below zero. At a temperature above freezing sliding resistance at low velocities gave results much below any on the opposite side of 32 deg. F. (see Fig. 2).

From the tests the following conclusions were drawn:

1. Sliding resistance of steel runners on an ice surface varies with temperature, but a large variation and probably most of the variation takes place through 32 deg. F.
2. Sliding resistance varies with velocity and with a great variation in low velocities at below freezing temperatures.

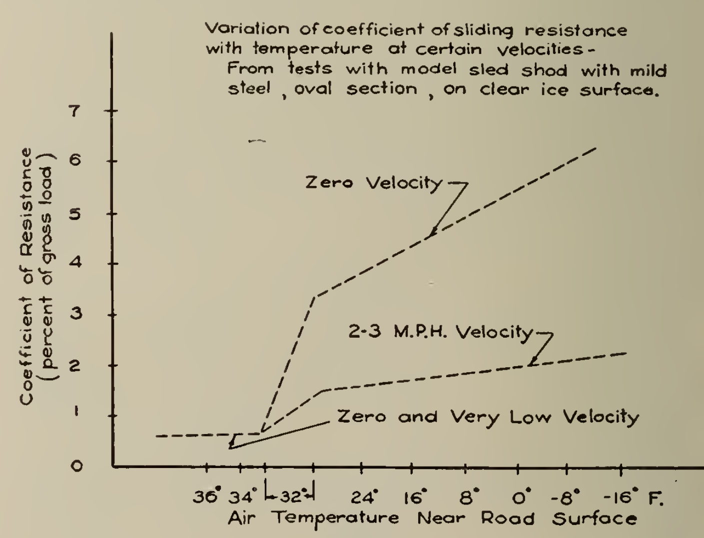


Fig. 1

3. Sliding resistance could be greatly reduced in below freezing temperatures by the application of water to the road, immediately before the runner passes.

There was no opportunity to try out "lubricating" a road in freezing temperatures but since the test was completed it has been found that one of the large paper companies practices this on at least one of its truck sleigh hauls by applying water to the road surface shortly before the trucks pass with loaded sleighs. An even more interesting case is that of a lumber company in Manitoba, where on a tractor sleigh haul, a water tank is drawn between

[1] Paper published in the Engineering Journal, September 1937.

[2] Canadian Pulp and Paper Association, Montreal.

tractor and loaded sleighs, with the water of the tank used to lubricate the road surface as necessary. Complete records of this operation are not available but it is known that a tractor with maximum draw-bar pull in low gear, of about 20,000 lb. (at 1.7 m.p.h.), has drawn loads of as much as 1,400 tons gross weight, indicating a sliding resistance of not more than about three-quarters of one

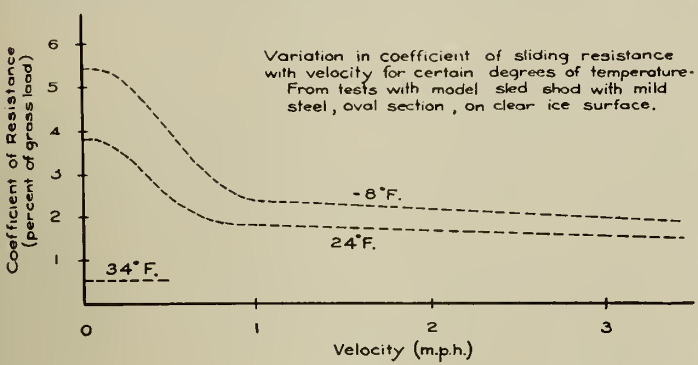


Fig. 2

per cent, and actually less as the tractor was able to work in higher gears over much of the road.

The lubrication of a winter road offers interesting possibilities. Using it a road might be deliberately located with a grade which would be insurmountable without lubrication. On a road in hilly country the "control" hill might be lubricated allowing greater loads to be hauled on each trip over all the road.

The low coefficient of friction at above freezing temperatures may seem to be of little interest in a winter hauling operation but on reflection, it will be found that there are numerous winter sleigh hauls which are carried on over short distances and with perhaps 5 to 10 round trips completed during the hours of daylight. On a sunny day even in the midst of winter the temperature of the air near the road surface is often above freezing and when this condition occurs sliding resistance will be at its lowest value. It seems possible that some practical use could be made of this and that loads on short hauls could be adjusted to the variations in sliding resistance.

The lowest possible value for rolling resistance of pneumatic tires, on the finest type of highway, is about one and one quarter per cent (25 lb. per ton), and on the usual dirt highway in undeveloped territory it is at least four per cent. It is of interest to know that it is possible to construct a temporary winter road, at comparatively low cost, over which loads can be hauled on sleighs with a resistance lower than the rolling resistance of the finest type of highway.

J. A. Freeland, A.M.E.I.C.[3]

Were bumping-poles used between the sleighs of the trains; the pictures did not indicate their presence.

W. J. Carson[4]

Further attention might be drawn to the heavy loads which it was possible to haul over winter roads. A load of 1,200 tons had been drawn at 6 m.p.h. with a draw-bar pull of only 6,000-7,000 lb. The difficulty lay in getting the load under way: once it was started, almost any load could be drawn.

John Chalmers, M.E.I.C.[5]

Was there any trouble experienced from side-sliding of the sleighs?

D. Forgan, A.M.E.I.C.[6]

The table of costs given in the paper was an eye-opener. On the Albany river near Pickle Crow, they had been unable to reduce the costs below forty cents per ton-mile: more usually it had been around sixty-five cents or higher. The value of well-made and well-protected roads should be stressed. It was often safer to use tractors without cabs, so that the drivers could jump clear in case the machine went through the ice.

O. Holden, A.M.E.I.C.[7]

The cost of transportation was a very vital matter. For example, in a 1,500 hp. power development on the Albany river the cost of transportation of materials from the railway represented no less than 20 per cent of the total cost of the work. Money was in general well-spent on improvements to navigation, and in one instance, by means of dams to drown rapids and marine railways and other improvements, the cost of transport was reduced from $60 to $20 per ton for a distance of about 160 miles.

J. B. D'Aeth, M.E.I.C.[8]

Special emphasis has been laid on the fact that a thoroughly good, competent and trustworthy organization must be employed. The reasons for this are:—

The winter freight hauling season is short—about three months.

The work is intermittent—that is, the organization generally cannot be held together during the entire year and one must know where good men are to be obtained when required.

While en route, the drivers are thrown on their own resources and have to get along the best they can with the equipment at their disposal. They are subjected to all sorts of weather and road conditions.

Mr. Townsend's experiments on winter road lubrication are extremely interesting and it is to be hoped that further experiments will be carried out along the lines already started. It will be noted that two haulage outfits have been making practical use of lubricating their roads to good advantage. One of these outfits has hauled 1,200 tons with a draw-bar pull of only 6,000 to 7,000 lb. In this particular case a second tractor had to help to get the load started.

In answer to Mr. Freeland, bumper poles were used between the sleighs. The usual connections between the sleighs are either cross chain connections with bumper pole or a pole connection of the T or the triangular type. There are usually cross chains or cross rods with bumper pole between the front and rear runners of a sleigh.

Trouble from side sliding or slewing as questioned by Mr. Chalmers is greatly reduced by rutting the road and by having solid shoulders. There is a tendency with fast truck-drawn sleighs to slew and the rear sleighs of the train to have a whipping action. This will occur where the road is wide and there are no ruts or shoulders to hold the runners in place.

On steep descending grades, there is a tendency for the train to buckle and become unmanageable. This is overcome by sanding the road, and if very steep, also by tying a chain around the last sleighs. This latter procedure is not desirable as it destroys the road.

The particular route mentioned by Mr. Forgan is known to be a bad one, being largely over lakes, which are very slushy and considered dangerous.

One of the troubles of freighting into the Red Lake and Pickle Crow districts is that the various concerns located there each lets a contract for its own needs. The result is that there are several hauling contractors operating in this district, none of whom can afford to build and maintain a good road. Each makes his own trail across the lakes with consequent high cost per ton mile.

[3] Forestry Department, Consolidated Paper Corporation Limited, Port Alfred, Quebec.
[4] Caterpillar Tractor Company, Peoria, Ill.
[5] Consulting Engineer, Montreal.
[6] Hydro-Electric Power Commission of Ontario, Toronto.
[7] Assistant Hydraulic Engineer, Hydro-Electric Power Commission of Ontario, Toronto.
[8] Chief Engineer, Fraser-Brace Engineering Company Limited, Montreal.

# THE ENGINEERING JOURNAL

## THE JOURNAL OF THE ENGINEERING INSTITUTE OF CANADA

"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."



VOLUME XX OCTOBER, 1937 No. 10

## Visiting The Institute Branches

The visits to the branches, which the officers of The Institute are able to make from time to time, play an important part in the policies of our organization. The branch news, published in The Journal, serves to picture the interests and activities of each branch, and shows how its operations are carried out in conformity with the requirements of its members. Gatherings such as the Round Table Conference of Branch Representatives, which has just concluded, aid by giving an opportunity for the free interchange of information and for active debate on matters of branch policy and on branch activities. There is, however, a need for more than this. The problems which the branches have in common; the results of the deliberations of Council and its committees; the aims of The Institute as a Dominion-wide body of engineers, are topics of the kind which can best be dealt with by personal visitation of the branches by the officers of The Institute. It is also important that so far as is possible these officers should be personally known to the branch officers, executive committees and members, and that it should be possible for them to answer inquiries and make explanations which will clear up points on which branch members desire information. For these reasons the journeys which successive Presidents (and in many cases vice-presidents) of The Institute have found it possible to make, have constituted a most valuable service to The Institute. The branches recognize this, and have invariably voiced their appreciation of such visits by the heartiest welcome, and by almost overwhelming hospitality.

To this issue of the Journal President Desbarats contributes some notes of his recent tour of the western branches. Travelling some five thousand miles, he has come back with the impression, shared by his predecessors who have made similar journeys, of widespread activity on the part of the branches and of their keen interest in the affairs of The Institute as a whole. From the President's notes it will be evident that he was able not only to meet the officers and members of the various branches, discussing with them many of the problems which face The Institute at the present time, but also to prepare and present to the readers of The Journal a concise survey of existing industrial conditions, on which the engineer's work is so largely dependent.

Canada is a country of such wide extent, and its various zones possess such a diversity of geographical and racial characteristics, that the promotion and maintenance of a broad Dominion-wide outlook should be the mission of every good Canadian. Such journeys as that which the President has just completed cannot fail to have great influence in this direction. They certainly help Institute members to realize that the branch to which they may belong is only a part (though an essential part) of a much larger organization, whose recognized national, and indeed international, status, was so clearly evidenced at The Institute's recent Semicentennial Celebrations.

## Annual General Meeting 1938 to be held in London, Ont.

The Council has accepted with pleasure the proposal of the London Branch that the Annual General and General Professional Meeting for 1938 shall be held in London, Ontario, at the end of January. The headquarters for the meeting will be at the London Hotel, and an energetic local committee is at work on the preliminary arrangements. The actual dates will be announced shortly.

A full programme of technical papers is being planned to feature two subjects of special interest in Ontario, namely; The Engineer and Highway Safety, and Flood Control in Ontario.

The choice of London as a meeting place for The Institute is appropriate, first, because it is the seat of one of our most active and enthusiastic branches, and, secondly, because its central location makes it easy for members to attend from the principal industrial areas of the province.

## The E.I.C. Engineering Catalogue 1937

The 1937 edition of the E.I.C. Catalogue is now being distributed to corporate members of The Institute whose duties involve the selection or approval of engineering equipment. It is also sent to a number of executive officers of important industrial and engineering organizations and to engineers and architects in the construction field.

In the volume now published, it will be found that there is a considerable increase in the number of firms represented and in the number of products described. The list of index subject headings, which has been drawn up on a comprehensive basis, with reference to all branches of engineering, includes some 3,000 entries dealing with a variety of materials, equipment and products, ranging, for instance, from abrasive materials and battery charging equipment to ventilating systems and zinc. Information as to their products has been furnished by some 3,900 individual firms.

The primary object of such a comprehensive catalogue is to provide in a single volume information which will give a list of the available sources of supply of the various types of equipment, materials, etc., and at the same time furnish such data regarding these products as will assist the purchaser in determining that best suited to his requirements.

# Notes by the President on his Western Trip

During the month of August I had the pleasure of visiting the Western branches of The Institute from Sault Ste Marie to the Pacific Coast. I wish to thank the members for the kind reception I received and for the many courtesies extended to my wife and myself.

It was very gratifying to observe the spirit of optimism and cheerfulness which prevailed generally among the members of The Institute. Business throughout the country is improving. Engineers felt the first effects of the depression and resulting slackening of manufacturing and construction and they are now profiting from the better conditions prevalent throughout the country.

*Sault Ste Marie:* Each branch visited put forward some new project or some improved conditions to justify their optimism. At Sault Ste Marie the Algoma steel plant, after a long shut down, had resumed operations and was running full time. The Helen iron mine to the north is being re-opened, the port of Michipicoten nearby on Lake Superior is being equipped to handle the large shipments of iron ore which are anticipated, and the paper mill is running full time. The locks at the Sault are handling very heavy traffic this year.

*Lakehead:* At Fort William the works of the Canada Car and Foundry Company which have been closed for years are now being utilized by an aeroplane factory. The Great Lakes Paper Company is operating full time with a machine turning out a sheet 304 inches wide, the widest in the world until recently when a wider machine was manufactured for a Scandinavian firm. Shipments of grain through this port will be light this year owing to the small crop, but the dry dock at Port Arthur reports good business with a large amount of ship repair work. The mining development north of this section helps the Lakehead cities, which are feeling fairly well off.

*Regina:* Regina, in the middle of the drought district, does not present such an attractive picture. The surrounding plains are dried up after seven rainless summers and crops were light or non-existent. As a result business was poor, but the community refuses to be cast down. They base their hopes on forecasts issued both from Ottawa and Washington prophesying the end of the dry cycle and the return of the years of good rainfall, with resulting abundant crops and renewed prosperity for Saskatchewan and the West.

The engineers here are fairly well occupied on maintenance work, highway construction, water conservation projects and investigations and experimental work for relief of drought conditions.

At Regina through the courtesy of the "Leader Post" I was given the opportunity of addressing a radio audience over Station CKCK and saying a few words about the aims and doings of The Engineering Institute and the work of the engineer.

*Lethbridge:* After leaving the burnt up countryside at Regina and Medicine Hat it was very pleasant to see the green irrigated fields of the Lethbridge district. Dairy farming and coal mining are Lethbridge's chief industries and both are doing well. There is a strong community spirit in Lethbridge, one of the irrigation systems is a community venture and the main hotel is also a community enterprise.

Throughout Alberta engineers are mainly occupied on maintenance work, as owing to the political situation it is difficult to obtain capital for any new enterprise and construction work is therefore pretty much at a standstill. Crops in Alberta are fairly good, and with higher prices for grains and dairy products, general conditions have improved considerably.

*Calgary:* An interesting development is proceeding in the Turner Valley, some 40 miles southwest of Calgary. The early wells at the north end of the valley produced wet gas with a small percentage of oil. The later wells, further south, are giving a higher proportion of oil and it is expected that by this fall the production will be sufficient to supply the needs of Alberta in gasoline and possibly have some for Saskatchewan. The gas is piped to Calgary, High River and the surrounding districts and some has been pumped into exhausted gas fields, but a large quantity of gas goes to waste. The wells are now being drilled about 6,500 ft. to the limestone in which the gas and oil are found and the cost of drilling a well is about $150,000.

*Edmonton:* The prospecting and mining development work now being carried on in the valley of the Mackenzie and its connecting lakes brings business to Edmonton and provides employment for engineers.

While in Edmonton I presided at the unveiling of a memorial sundial erected on the power plant grounds as a tribute to the late W. J. Cunningham, M.E.I.C., former superintendent of the Edmonton power plant. The mayor, civic officials and members of The Institute took part in the ceremony, showing the esteem felt for Mr. Cunningham by his fellow citizens and fellow engineers.

*Victoria and Vancouver:* In British Columbia a good deal of government work was in progress. The Dominion Government is building the last link of the western half of the Trans-Canada highway around the big bend of the Columbia between Golden and Revelstoke. This is a heavy job and will not be completed for a couple of years. The Dominion Government is also completing the stations and landing fields of the Trans-Canada Airways. At New Westminister the new highway bridge over the Fraser is nearing completion; this will replace the present inadequate bridge leading to the highway system of the Western States. A British company is building a bridge over the First Narrows from Stanley Park to North Vancouver. The caissons for the piers are being built and work is proceeding on the approaches. The same interests are developing a large area on the north shore of the Inlet for residential purposes. The plans are on a lavish scale.

*Winnipeg:* Manitoba was rejoicing in a reasonable harvest and with government public works there was good demand for labour. Engineers in Winnipeg are faced with a foundation problem. Owing to the succession of dry seasons and as a result of city drainage, the clay subsoil has dried up and shrunk and the medium class of buildings are settling badly, necessitating expensive underpinning. The Winnipeg branch of The Institute have appointed a committee to study the question and, working with committees from other societies, have produced a valuable report on the causes of this trouble and have suggested means of avoiding it. Another committee has been appointed to study the related subject of ground water conditions in Winnipeg. The Winnipeg Branch is to be congratulated on the public spirit it shows in undertaking this work; other Branches could follow their example with profit.

At each Branch visited I gave a short talk about the work and aims of The Institute. I discussed the vote on the proposals put forward by the Committee on Consolidation and pointed out that while these proposals had been rejected, the discussion at the Plenary Meeting of Council showed that The Institute was anxious to have the greatest possible measure of co-operation with the Provincial Professional Associations. I described the recently appointed Committees on "Professional Interests" and "Membership and Management" with their personnel and their objects. I gave a description of the Semicentennial Meeting, mentioning its success and the high standing of the delegates from other engineering societies, stressing the high position held by The Institute in the scientific and engineering world, and the advantage to Canadian engineers of possessing a well-established national society. I also gave a statement of the finances of The Institute.

These talks seemed to be well received by the members. At three of the Branches ladies attended the meetings and I hope they were not bored by what must have been to them a rather dull talk.

At each Branch visited I found the friendliest relations existing between members of The Institute and members of the Professional Associations and a large measure of cooperation in existence. Marked interest was displayed in the work of the two committees appointed by Council and the belief was expressed that they would be of great benefit to The Institute.

Every Branch professed a desire for frequent relations with headquarters and visits from officers of The Institute. They urged that members of The Institute travelling through the west should arrange to stop over and give addresses to some of the Branches.

I wish again to express my appreciation of the kind way in which I was received by the Branches, of the attention given to my talks and of the trouble taken by the officers in arranging meetings and entertainments, and I trust these visits will be of some advantage to The Institute and to its Branches.

G. J. Desbarats,
*President.*

# OBITUARIES

## Charles Francois Xavier Chaloner, M.E.I.C.

The death of Charles Francois Xavier Chaloner occurred in October 1936 and will be noted with regret, particularly by the older members of The Institute.

Mr. Chaloner was born in Quebec on March 5th, 1861, and was educated at St. Anne de la Pocatière College and Laval University. He became a Member of The Engineering Institute in February 1887. In 1880 he was appointed to the engineering staff of the Public Works Department, with R. Steckel, as first assistant engineer in the inauguration of precise levelling in Canada. As assistant engineer he was on the first hydrographic survey made of the St. Lawrence river and as principal assistant engineer was on precise levelling during the years 1883 to 1904. From 1904 to 1908 he was in charge of the Georgian Bay precise levelling party. In 1910 he was appointed engineer-in-charge of this work and was actively engaged until his retirement in 1931, completing a stretch of over 50 years continuous service.

## Samuel Ernest McMillan Henderson, M.E.I.C.

It is with deep regret that members of The Institute, particularly those in Toronto, will note the death of Samuel Ernest McMillan Henderson, m.e.i.c., who died on September 2nd, 1937, after a short illness.

Mr. Henderson was born at London, Ontario, September 8th, 1879, and graduated from the University of Toronto (School of Practical Science) in 1900. He joined the General Electric Company at Schenectady, N.Y., in 1900, first in the drafting room; he then became a designing engineer and later engineer on the manufacture and inspection of the original Hydro-Electric Power Commission of Ontario installation. In 1910 he was placed in charge of the design and engineering on the meters, switchboards, etc., of the Canadian General Electric Company; in 1913 he was appointed electrical engineer for the above company,

S. E. McM. Henderson, M.E.I.C.

latterly becoming manager of the switchgear section apparatus sales department.

Mr. Henderson joined The Institute as a Member in 1929.

## Thomas James Fleming King, A.M.E.I.C.

It is with regret that we record the death of Thomas James Fleming King, a.m.e.i.c., which took place in Quebec on August 16th, 1937, after some months of illness.

Mr. King was born at Everton, England, in 1879 and graduated from the Glasgow and West of Scotland Technical College. He came to Canada in 1906 where his first position was on the design of smelter layout for the Mond Nickel Company, Victoria Mine, Ontario. He then entered railway work in Canada and in 1908 was appointed resident engineer on the construction of the Atlantic, Quebec and Western Railway. He was later with the Intercolonial Railway and from 1910 to 1912 was in the division engineer's office of the Canadian Pacific Railway at Montreal and North Bay, Ontario. In 1912 he joined the engineering

T. J. F. King, A.M.E.I.C.

staff of the Canadian Government Railways as assistant engineer on location, later becoming office engineer, then acting assistant engineer and finally assistant engineer of the Canadian National Railway for the Quebec District.

Mr. King at the time of his death was vice-chairman of the Quebec Branch of The Institute.

### William Frederick McLaren, M.E.I.C.

We announce with deep regret the sudden death of William Frederick McLaren, on Thursday, August 19th, 1937, at his home, "Balquhidder," Ancaster, Ontario.

Mr. McLaren, at the time of his death, held the position of chief draughtsman of the Canadian Westinghouse Company at their offices at Hamilton. He was born at Hamilton, Ontario, on May 21st, 1871, and was a graduate of the Royal Military College, Kingston, Ontario, and subsequently of Cornell University, graduating from the latter institution in 1894. Following this he took the engineering course of the Westinghouse Electric and Manufacturing Company for a period of eighteen months, after which he was engaged in power plant operation in Revelstoke and at Bonnington Falls, B.C. In 1901 he re-entered the service of the Westinghouse Company at East Pittsburgh and was then continuously in the service of that company until his death.

A highly skilled member of the engineering profession, he served in the Canadian Westinghouse not only as chief draughtsman but also as principal mechanical engineer.

Due to his modesty, only his close associates knew of his outstanding ability in engineering as applied to the mechanical construction of electrical apparatus, especially

W. F. McLaren, M.E.I.C.

large generators and motors. His quiet courtesy and tact won the respect of all those associated with him.

Mr. McLaren became a Member of The Engineering Institute of Canada in 1918 and played a large part in upholding the standard of the Hamilton Branch. He was secretary-treasurer of the Branch for six years, later becoming chairman.

He went overseas during the Great War with the 164th Halton and Dufferin Battalion with the rank of Captain.

### Stewart Sterling Oliver, M.E.I.C.

In the passing of Stewart Stirling Oliver in Quebec, on August 17th, 1937, Quebec city loses one of its oldest engineers and The Engineering Institute of Canada one of its oldest members.

Mr. Oliver was born in Quebec on April 9th, 1858, and was educated in that city, receiving a certificate as a Quebec Land Surveyor in 1880. In 1884 he became assistant engineer on surveys and location for the Quebec and Lake St. John Railway. In 1894 and 1895 he was engineer in charge of construction on the St. Juliane and St. Maurice sections of the Great Northern Railway. From 1896 to 1907 he acted as auditor for the Quebec and Lake St. John Railway and in 1908 and 1909 was engineer of maintenance of the Canadian Northern and Quebec and Lake St. John Railways. From 1910 to 1917 he was in private practice and also right of way engineer for the Quebec Railway Light and Power Company and for the Quebec and Saguenay Railway. In 1918 he became purchasing agent for the Quebec Light, Heat and Power Company, and retired in 1930.

Mr. Oliver joined The Institute as an Associate Member in 1887, becoming a Life Member in 1931. He acted as secretary of the Quebec Branch of The Institute in 1911 and chairman in 1912.

### Jeremiah James Macdonald. M.E.I.C.

We deeply regret to have to announce the death on September 4th, 1937, of Jeremiah James Macdonald, M.E.I.C., an outstanding Canadian engineer and at the time of his death chief engineer with Sir Alexander Gibb and Partners, London, England.

Mr. Macdonald was born at Vernon, P.E.I., on February 1st, 1882, and graduated with the degree of B.Sc. from McGill University in 1911. Prior to and during his university course, he was engaged on preliminary and location surveys on the Transcontinental and Canadian Northern Railways. In 1911 and 1912 he was with Waddell and Harrington, consulting bridge engineers, in Kansas City, Mo., engaged in the design of lift bridges and reinforced concrete structures, bridges and viaducts. In 1913 he acted as lecturer in mathematics and demonstrator in the civil engineering department of McGill University. From 1913 to 1916 he was office engineer for the Halifax Ocean Terminals in charge of structural design. From 1917 to 1918 he was assistant engineer for the Canadian Government Railways at Moncton and in 1918 and 1919 was resident engineer in charge of the installation of sewerage and water systems and the construction of reinforced concrete carshops in connection with the Halifax Ocean Terminals.

In 1919 Mr. Macdonald became chief engineer of design for W. Alban Richards, engineers and contractors, London and Paris, where his work included the construction of important works, notably the extension of the Royal Edward Dock at Avonmouth and large grain elevators for the same port. In 1923 he became construction engineer with the J. G. White and Company Limited, London, England, and had charge of the construction of the steam-electric power station for the London County Council at Barking. He also directed extensive sanitation and harbour works in South America for this company. In 1925 he was engaged on the difficult foundation work on the bridge across the River Tyne at Newcastle under Sir Douglas Fox and Partners for Dorman Long and Company.

In 1926 Mr. Macdonald returned to Canada and was appointed chief engineer of the Foundation Company of Canada Limited with headquarters in Montreal and in 1930 was appointed chief engineer of the Halifax Harbour Commission. While with this Commission he was called upon by the Federal Government to take charge of the reconstruction of the docks at Saint John, New Brunswick, after the disastrous fire, and did that work with great credit to himself and the organization with which he surrounded himself. The expenditure on the works in question amounted to over ten million dollars.

On completion of this work Mr. Macdonald returned to his duties with the Halifax Harbour Commission but a short time after was invited to join the staff of Sir Alexander Gibb and Partners, consulting engineers, London, England, where he was responsible for the design, supervision and construction of several large projects in England, Wales and other countries, most notably the rehabilitation of industries in Wales and the northeast coast of Great Britain.

Mr. Macdonald joined The Engineering Institute of Canada as a Student in 1911, became an Associate Member in 1914 and a Member in 1920.

## PERSONALS

W. Clyde Baggs, S.E.I.C., has recently received an appointment with the Bathurst Power and Paper Company Limited, Bathurst, New Brunswick. Mr. Baggs, whose home is in Curling, Newfoundland, graduated from Mount Allison University and subsequently from McGill University in 1936.

F. W. Bradshaw, A.M.E.I.C., has received an appointment as assistant to the chief engineer of the Consolidated Paper Corporation Limited, Grand'mère, Quebec. Mr. Bradshaw graduated with honours in chemical engineering from McGill University in 1925 and prior to and since graduation has had extensive experience in the pulp and paper industry. From 1925 to 1930 he acted as assistant to the mechanical superintendent of the Riverbend mill of Price Brothers and Company Limited, except for a six months period as assistant to their research engineer at Quebec. From 1930 to 1932 he was chemical engineer at the Jonquière mill of the same company. Between 1932 and 1934 Mr. Bradshaw was with the Carleton Mills Limited, Carleton Place, Ontario, and Beardmore Leathers Limited, Acton, Ontario. In 1934 he joined the Consolidated Paper Corporation as development engineer in their research and technical department at Three Rivers, Quebec.

Eric M. Coles, A.M.E.I.C., has been appointed assistant to the vice-president of the Canadian Westinghouse Company, Hamilton, Ontario. Mr. Coles graduated in mechanical engineering from the University of British Columbia in 1922. He then became instructor and later assistant professor of electrical engineering in the same University. Mr. Coles joined the Canadian Westinghouse Company as design engineer in the synchronous motor and generator section of the engineering department and in 1928 was placed in charge of all patent activities of the company. He served overseas during the War with the Royal Air Force and was awarded the Distinguished Flying Cross. Mr.

Eric M. Coles, A.M.E.I.C.

Coles has been active in the Hamilton Branch of The Institute for a number of years.

G. Sandford Davis, M.E.I.C., has been appointed assistant electrical engineer of the Department of National Defence in Ottawa. Prior to this appointment, Mr. Davis was electrical engineer with J. M. Robertson and Company, Montreal, with whom he has been connected since 1920. From 1905 to 1920 he was with the Canadian General Electric Company, as erecting and later design engineer.

P. C. Hamilton, S.E.I.C., has been appointed district engineer with the Gunite and Waterproofing Limited and Construction Equipment Company Limited with headquarters in Halifax, Nova Scotia. He was previously with the Avon River Power Company Limited, having graduated from the Nova Scotia Technical College in 1933.

W. G. Hamilton, S.E.I.C., recently severed his connection with the Tashota Gold Fields Limited, and is now mill superintendant and chief assayer at the Mine Apprentice Project, Lacey Gold Mine, Chester Basin, Nova Scotia. Mr. Hamilton graduated from the Nova Scotia Technical College with the degree of B.E. in Mining in 1935.

A. H. Pask, Jr.E.I.C., formerly with the Eagle Pencil Company Limited, Drummondville Quebec, is now located in Windsor, Ontario, where he is in the engineering department in the salt and general chemicals plant of the Canadian Industries Limited. Mr. Pask graduated from the University of Manitoba in electrical engineering in 1935.

M. E. Tregarthen, A.M.E.I.C., has recently received the appointment of assistant electrical engineer in the Department of Road Transport and Tramways, Sydney, Australia. This department controls the tramways and trolley bus system in New South Wales. Mr. Tregarthen was previously assistant engineer with the Department of Public Works of New South Wales. From 1927 to 1928 he was in Canada and associated with the Canadian Comstock Company. Mr. Tregarthen graduated from Sydney University in 1921 with the degree of B.E. in Mechanical and Electrical Engineering.

Keith B. Wallace, S.E.I.C., a graduate in mechanical engineering of McGill University in 1930, has left the Dominion Oilcloth and Linoleum Company, Montreal, where he has been employed since graduation, and is now with Barry and Staines Linoleum (Canada) Limited at Farnham, Quebec.

C. R. Young, M.E.I.C., Professor of Civil Engineering in the University of Toronto, has been appointed a member of the Royal Commission on Highway Transport recently named by the Ontario Government, the other members being Mr. Justice E. R. E. Chevrier, of the Supreme Court of Ontario (Chairman), and Mr. E. R. Sayles, publisher, of Renfrew, Ontario. This Commission is charged with the task of investigating and reporting on the operation of motor vehicles for gain in the transportation of freight and passengers in the Province, and the relation thereto of all competing forms of transport.

#### New Appointments, The Dominion Bridge Company, Limited

The Dominion Bridge Company, Limited announce a number of new appointments in Montreal effective October 1st, 1937:—

F. P. Shearwood, M.E.I.C., a past-president of The Institute, has been appointed consulting engineer of the company. He commenced his connection with the organization in August, 1887, as a draughtsman and was subsequently transferred to the Designing Department. He has held successively the positions of designing engineer, assistant chief engineer and chief engineer.

Mr. Shearwood is widely known in engineering circles for his association with the design and erection of many of the important bridges and other structures in Canada. He has been a member of The Engineering Institute for forty-five years; was treasurer for five years, president in 1934 and has served on the Council as vice-president and councillor for ten years.

Mr. Shearwood recently celebrated the fiftieth anniversary of his joining the company and much satisfaction is expressed that his wide experience is still available to the company in a consulting capacity.

Fred Newell, M.E.I.C., has been appointed chief engineer of the Dominion Bridge Company, Limited.

Mr. Newell was educated at the London and Woolwich Polytechnic School and received a Whitworth Exhibition in 1902. After several years' engineering experience in England he came to Canada and shortly after his arrival joined the Dominion Bridge Company, Limited, in 1908 as a designer in the Mechanical Department. Since that time he has held successively the positions of chief mechanical engineer and assistant chief engineer. He joined The Engineering Institute in 1916 as an Associate Member and has served on the Council for five years.

F. P. Shearwood, M.E.I.C.

F. Newell, M.E.I.C.

R. S. Eadie, M.Sc., M.E.I.C., has been appointed assistant chief engineer of the Dominion Bridge Company, Limited. On completion of his university course, Mr. Eadie lectured for four years in the Faculty of Applied Science of McGill University. He joined the Dominion Bridge Company, Limited, in 1924 and as a designer in the Bridge and Structural Department he has been intimately associated with many important structures built by the company during the past few years.

Mr. Eadie has been a member of The Institute since 1914, when he joined as a Student.

D. B. Armstrong, A.M.E.I.C., has been appointed Designing Engineer of the Dominion Bridge Company, Limited. He joined the company in 1909 as a draughtsman and has successively held the positions of designer, erection engineer and engineer in charge of special projects. He was closely associated with the design and erection of the Jacques Cartier bridge and latterly has occupied the position of engineer in charge of the Island of Orleans suspension bridge. He joined The Institute as an Associate Member in 1923.

## The Round Table Conference of Representatives of Branches of The Institute

### June 14th, 1937

One of the principal items of business at the meeting of the Council of The Institute held on September 24th, 1937, was the consideration of the report of the proceedings of the Round Table Conference which was held on June 14th, 1937; was attended by delegates from twenty-four of The Institute branches, and was called to afford an opportunity for the free discussion of questions of branch operation and management, including certain points affecting the membership as a whole.

The actual programme of this conference was based on suggestions received from branch committees, indicating matters of common interest, and covered a great variety of topics. During the three sessions of the conference there was a most instructive general interchange of views and information, a feature whose particular value will be appreciated in view of the great diversity of outlook and operating conditions which must characterize a series of branches extending from Cape Breton to Vancouver Island. Such discussions, or their equivalent, are indispensable if the widely spread membership of The Institute is to act collectively as a Dominion-wide organization.

In opening the proceedings, the chairman of the conference, Mr. Huet Massue welcomed the following delegates:

Representing the Branches:—

| | | |
|---|---|---|
| Cape Breton | Mr. M. R. Chappell | Chairman |
| Saint John | Mr. J. R. Freeman | Chairman |
| Moncton | Mr. H. J. Crudge | Member of Council |
| Saguenay | Mr. F. L. Lawton | Vice-Chairman |
| Quebec | Mr. Alex. Larivière | Chairman |
| St. Maurice Valley | Mr. C. H. Champion | Sec.-Treasurer |
| Montreal | Mr. C. K. McLeod | Ex-Sec.-Treasurer |
| Ottawa | Mr. Ephrem Viens | Ex-Officio |
| Peterborough | Mr. H. R. Sills | Chairman |
| Kingston | Mr. R. F. Legget | Executive |
| Toronto | Mr. A. U. Sanderson | Vice-Chairman |
| Hamilton | Mr. W. J. W. Reid | Vice-Chairman |
| London | Mr. A. O. Wolff | Chairman |
| Niagara | Mr. Walter Jackson | Member of Council |
| Border Cities | Mr. E. M. Krebser | Vice-Chairman |
| Sault Ste. Marie | Mr. J. Lang | Ex-Officio |
| Lakehead | Mr. G. R. Duncan | Vice-Chairman |
| Winnipeg | Mr. H. L. Briggs | Sec.-Treasurer |
| Saskatchewan | Mr. Stewart Young | Vice-Chairman |
| Lethbridge | Mr. P. M. Sauder | Chairman |
| Edmonton | Mr. W. E. Cornish | Executive |
| Calgary | Mr. Jas. McMillan | Sec.-Treasurer |
| Vancouver | Mr. H. N. Macpherson | Chairman |
| Victoria | Mr. I. C. Barltrop | Ex-Officio |

The Recording Secretary was Mr. E. R. Smallhorn, Secretary-Treasurer of the Montreal Branch.

There were also present by invitation:

| | | |
|---|---|---|
| Mr. J. B. Challies | Councillor | 1920-22 |
| | Vice-President | 1924-25 |
| | Treasurer | 1934-36 |
| Mr. P. L. Pratley | Councillor | 1927-29, 1932-34 |
| | Vice-President | 1935-36 |
| | Treasurer | part of 1932-33 |
| and Mr. E. A. Ryan | Councillor | 1935-36-37 |
| | Ex-Chairman, Montreal Branch | |
| | Chairman, Institute Membership Committee | |

These gentlemen, by their experience and knowledge of Institute affairs, were well equipped to give first hand information on many points which arose during the discussions.

Copies of the full report of the conference, prepared by Mr. Smallhorn, have been placed in the hands of all delegates, all branch secretaries, all branch chairmen, and all members of Council.

At the meeting of Council, the study of the twenty-six pages of this report with its appendices, occupied nearly the whole evening. Members present were unanimous in expressing appreciation of the excellent judgment with which the various topics had been selected, and the constructive nature of the discussions to which they gave rise.

The following brief notes on the various sections of the report and the views expressed thereon at the meeting of Council will be of interest to the membership:

1. *Uniformity in Dates of Branch Elections.*

Having noted the conference discussion on this point, Council strongly recommended that the branches should endeavour to have their fiscal years coincide with that of The Institute, and that the dates of election of branch officers should if possible agree with that of The Institute.

2. *Method of Election of Branch Secretaries and Officers.*

In Council's opinion the branches might well take action along the lines of the discussion, namely, that branch secretaries and committee chairmen should be appointed rather than elected.

3. *Term of Office of Officers.*

Council agreed with the feeling expressed at the conference, namely, that there should be no objection to the re-election of any branch officer, but also that as many members as possible should be encouraged to take an active part in the direction of branch affairs.

4 (*a*). *Rebates from Headquarters.*

In regard to a possible revision of the present scale of rebates, Council gathered that the present scale was not altogether satisfactory, particularly to the smaller branches, and it was decided that the question of its revision should be referred to the Committee on Membership and Management, which has recently been appointed.

4 (*b*). *Financial Years.*

With regard to the final statement of the rebates due to the branches at the end of the calendar year, it was pointed out that this figure could not be given by Headquarters until after December 31st, the end of The Institute's financial year, but the Secretary was directed to let the branches have this information as early as possible in January.

4 (*c*). *Classification of Branch Accounts*

Mr. McMillan (Calgary) having pointed out the difficulty of making any comparison of the accounts of the various branches, submitted to the conference a proposed standard method for classifying branch income and expenditure (Appendix B to the report of the conference). Council agreed with the conference that the adoption of a uniform method of classifying accounts would be very desirable, and referred the matter to the Finance Committee for consideration and consultation with Mr. McMillan, with a view of preparing definite recommendations.

4 (*d*). *Arrears of Fees.*

In order to facilitate branch co-operation in the collection of arrears of fees, the conference had recommended that copies of the General Secretary's letters to branch secretaries regarding this matter should be sent to the local councillors for their information. This suggestion was approved by Council.

5. *Membership Committees.*

Council noted the explanations given to the conference by Mr. Ryan, chairman of The Institute's Membership Committee, and fully agreed with the opinion expressed at the conference that the councillor of each branch should be an active member of the branch application and credentials committee so that he will be acquainted with the details of any unusual case coming before Council.

6. *Resignations and Admissions.*

In regard to the suggestion made at the conference that after a member has resigned he should surrender his certificate of membership, the Secretary explained to Council that although at the present time no request was made for the return of members' certificates, such requests had been made for a number of years in the past. It was found that the certificates were returned in very few cases, however, and the practice had therefore been discontinued. Council considered it advisable to retain the present practice of not asking for the return of the certificate.

7. *Speakers, Meetings and Publication of Papers.*

The Council was particularly interested in the discussion which had taken place at the conference regarding the securing of speakers and papers for the various branches of The Institute. It was pointed out that the principal difficulty in this connection was the impossibility of obtaining advance information as to members' intended movements. The President hoped that senior members of The Institute would make a point of addressing the members of the various branches through which they might pass when travelling on business, or, at all events, that they would get in touch with the officers of the local branch when visiting any branch centre.

It was suggested that possibly a questionnaire might be sent out at the beginning of each year to members of Council and senior members of The Institute asking to be informed of any journeys which they would probably make during the coming year. It was also considered most desirable that the vice-presidents should visit the branches in their respective zones.

Attention was drawn to the possibility of closer co-operation between the branches as regards the interchange of papers; an author presenting a paper before the Toronto Branch, for instance, might well be asked to give it also in Montreal or Ottawa.

After further discussion it was decided to draw the attention of the chairman of the Papers Committee to the discussion at the Round Table Conference and at the Council meeting, and to inform the Papers Committee and the branches that the Council is anxious to do everything possible to support the branches in their activities, particularly as regards speakers and technical papers.

8. *Membership on Executive Committees of Ex-Officio Officers.*

Council noted the request of the conference to consider a revision to Section 13 of the By-laws, under which councillors representing branches entitled to three councillors hold office for more than two years. Council was of opinion that this point should be considered by the Committee on Membership and Management.

9. *Elections.*

The question having been raised at the conference as to the signatures on ballot envelopes, Council agreed with the suggestion that the outer envelope should have space for the signature as well as for the printed or typed name of the voter.

10. *Relation between Council and Branch Executive Committees.*

Council noted that at the conference several speakers had referred to the desirability of having some officer of The Institute visit each of the branches each year. Council was in entire agreement with this idea, and it was pointed out that under Item 7 Council would encourage the vice-presidents to visit each year the branches in their respective zones.

It was noted that in the opinion of the conference the mark "Confidential" on minutes of Council was liable to misconstruction, and had, in some cases, prevented councillors from discussing Institute affairs with their branch executive committees. For this reason Council resolved that in future the sheets shall not be marked "Confidential" and that it should be left to the discretion of the councillors as to those items in Council minutes which should be treated confidentially.

11. *Provincial Divisions of The Institute.*

Following the discussion at the conference as to the desirability of forming Provincial Divisions of The Institute, Council resolved to refer this matter to the Committee on Membership and Management for consideration and report.

12. *Relations to Other Societies.*

It was decided by Council that the discussion on this subject should be referred to The Institute's Committee on Relations with National Societies.

13. *Employment Bureau.*

One of the suggestions made at the conference had been that The Institute should undertake a survey of industry's requirements for graduate engineers, and that the resulting information should be made available to undergraduates prior to their decision as to the branch of engineering they wish to study.

Considerable discussion took place on this point, and while it was felt that it would be impossible for The Institute to undertake a survey of this kind, it was decided that the Secretary should endeavour to secure from the various universities, at the beginning of each college year, information as to the registration in the various branches of engineering, such information to be published in The Journal.

14. *The Journal.*

It was noted with appreciation that considerable discussion had taken place at the conference regarding The Journal, and that Mr. R. F. Legget had prepared a written statement of his views, which had been attached to the report of the conference as Appendix A.

Following the resolution passed at the conference, recommending the study of the whole question of The Journal, it was suggested, after considerable discussion, that the whole subject of the publications of The Institute might with advantage be studied by a small active committee, and it was decided that all members of Council should be asked to submit their views on this point and on the personnel of this committee, for consideration by Council at its next meeting.

Attention was drawn to the elaborate inquiry on this matter made in 1928-29 and the report on the publications of The Institute which had been presented at the Fourth Plenary Meeting of Council in 1930, the present set up of The Journal being based as far as possible on this committee's recommendations.

Following this discussion, the Council resolved that a hearty vote of thanks and appreciation be extended to the committee in charge of the Round Table Conference in recognition of the valuable work which had been accomplished, as evidenced by the report of the proceedings of the conference.

Further, The Secretary was directed to inform the various branches, and the delegates who attended the meeting, as to the action taken by Council in regard to the points discussed at the conference.

## A New Membership List

It is intended to issue a new List of Members early in 1938. The utility and completeness of such a list depends on the extent to which individual members will assist by furnishing the information requested in the enquiry cards which have been sent out to members of all classes.

The Secretary begs that everyone will make a point of co-operating in this manner. It is especially desirable that the list shall contain, in *all* cases, the member's official position, the name of the organization employing him, and an indication of the branch of engineering with which he is concerned.

## Elections and Transfers

At the adjourned meeting of Council held on September 27th, 1937, the following elections and transfers were effected:—

*Members*

HARRINGTON, Arthur William, C.E. (Cornell Univ.), District, Engineer, U.S. Geological Survey, Albany, N.Y.

IZARD, Edward Whitaker (Glasgow Univ.), works manager, Yarrows Ltd., Victoria, B.C.

RELYEA, John DeWitte, B.A.Sc. (Univ. of Toronto), Department of Public Works, Toronto, Ont.

*Associate Members*

CONNOR, Gerald Russell, B.A.Sc. (Univ. of Toronto), instr'man., steam dept., Spruce Falls Power and Paper Co. Ltd., Kapuskasing, Ont.

HOOGSTRATEN, Jack, B.Sc. (Univ. of Man.), lecturer in civil engrg., Univ. of Manitoba, Winnipeg, Man.

MANLEY, Edward Hugh, B.Sc. (Syracuse Univ.), constrn. supt. Aluminum Company of Canada, Arvida, Que.

PEACHEY, Cyril Arthur, B.A. (Univ. of Toronto), mfg. engr., Northern Electric Co. Ltd., Montreal, Que.

*Juniors*

ADAMS, John DeWitt, B.Sc. (Univ. of Alta.), dftsman., Dept. of Highways of Ontario, London, Ont.

BORBEY, John Pierre, B.A.Sc. (Univ. of Toronto), designer, Dominion Bridge Co. Ltd., Montreal, Que.

BYERS, William Caryl, B.Sc. (E.E. and C.E.), (Univ. of Man.), Dept. of Public Works, Kenora, Ont.

DUBESKY, William, B.Sc. (Univ. of Man.), supt. and engr., Radio Oil Refineries Ltd., Winnipeg, Man.

GEORGE, Joseph David, B.E. (Univ. of Sask.), 1331 Henry St., North Battleford, Sask.

GRAY, Harry Alden, B.Sc. (Univ. of Man.), 1316 Dorchester St. West, Montreal, Que.

KERRY, Frank George, B.Eng. (McGill Univ.), service engr., Canadian Liquid Air Co., Montreal, Que.

LOVE, Herbert W., Lieut., R.C.E., B.Sc. (Queen's Univ.), engr. i/c Dominion Arsenal, Valcartier, Que.

McCAREY, Joseph Newell, B.Sc. (Queen's Univ.), technical staff, Canadian International Paper Co., Temiskaming, Que.

QUINN, Odoric Charles (McGill Univ.), engrg. secretarial work, Price Bros. & Co. Ltd., Riverbend, Que.

RYAN, Edward, B.Sc. (Queen's Univ.), 232 Sydenham St., Kingston, Ont.

SAMIS, George Roy, B.A.Sc. (Univ. of Toronto), designer, Dominion Bridge Co. Ltd., Montreal, Que.

SCRIVENER, Richard Harding, B.A.Sc. (Univ. of Toronto), designer, Dominion Bridge Co. Ltd., Montreal, Que.

WEIR, William Cecil, B.E. (Univ. of Sask.), mech. engr., Hudson Bay Mining and Smelting Co., Flin Flon, Man.

*Affiliate*

WESTOVER, Channing Spaulding, instr'man., Aluminum Company of Canada, Arvida, Que.

*Transferred from the class of Associate Member to that of Member*

BUNTING, William Russell, B.A.Sc. (Univ. of Toronto), power apparatus specialist, Northern Electric Co. Ltd., Montreal, Que.

LAWSON, Horace Hetherington, Major (Grad., R.M.C.), B.Sc. (Queen's Univ.), O.L.S., assoc. professor of engineering, Royal Military College, Kingston, Ont.

REID, William Joseph Walter, B.A.Sc. (Univ. of Toronto), works manager, The Otis-Fensom Elevator Co., Hamilton, Ont.

STUART, William Grey (Glasgow Univ.), power reconnaissance engr., 10335–117th St., Edmonton, Alta.

TOOVEY, Thomas William (R.P.E. of B.C.), technical adviser to chlorine sales dept., Pennsylvania Salt Manufacturing Company, Philadelphia, Pa.

*Transferred from the class of Junior to that of Associate Member*

DUNCAN, Conrad Munro, B.Sc. (Univ. of Man.), 28 Gilmour St., Ottawa, Ont.

EVANS, John Maurice, B.Sc. (McGill Univ.), engr., Dept. of Development, Shawinigan Water and Power Company, Montreal, Que.

*Transferred from the class of Student to that of Associate Member*

SAINT JACQUES, Jean, B.A.Sc., C.E. (Ecole Polytechnique, Montreal), B.Sc. (McGill Univ.), office engr., Quebec Power Company, Quebec, Que.

*Transferred from the class of Student to that of Junior*

BRIDGE, David E., B.A.Sc. (Univ. of Toronto), instructor in industrial maths., Hamilton Technical Institute, Hamilton, Ont.

FULLERTON, Roland McNutt, B.Sc. (N.S. Tech. Coll.), electrician, Canadian Malartic Gold Mines, Malartic, Que.

*VILLEMURE, J. Phileas, dftsman. and instr'man., City of Grand' Mère, Que.

*Students Admitted*

DOLAN, Michael Aloysius, B.Sc. (Queen's Univ.), 1 Aberdeen Ave., Kingston, Ont.

DUNN, John Thomas, B.A.Sc. (Univ. of Toronto), 131 King St. East, Ingersoll, Ont.

LEVINE, Samuel Dave (Univ. of Toronto), 62 Brunswick Ave., Toronto, Ont.

LOUTIT, John Alexander (Univ. of Man.), 51 Gloucester St., Ottawa, Ont.

VAN EVERY, Hugh Davidson, ap'tice dftsman., Dominion Bridge Co. Ltd., Montreal, Que.

*Has passed The Institute's examinations.

## BULLETINS

*Fuses.*—Two bulletins received from A. Reyrolle & Company, England (representatives: Northern Electric Company), discuss their lines of cartridge fuses for a.c. and d.c. circuits.

*Switchgear.*—A. Reyrolle & Company, England (representatives: Northern Electric Company), have issued an 8-page bulletin giving particulars of their metal clad switchgear, class B. up to 15,000 volts with compound-filled bus-bar chambers.

*Induction Motors.*—An 8-page bulletin from J. H. Holmes & Company, England (representatives: Northern Electric Company), contains details of their types L.C. slip-ring induction motors.

*Generators.*—An 8-page bulletin from J. H. Holmes & Company England (representatives: Northern Electric Company), deals with heavy-current low-voltage generators for electrical work.

*Printing Press Equipment.*—A number of bulletins issued by J. H. Holmes & Company, England (representatives: Northern Electric Company), describe electrical equipment used in printing offices. This includes unit and group drives, controls, web-breakage detectors and reel-stands.

*Steel Hard-Facing.*—An 8-page bulletin has been received from the Dominion Oxygen Company Limited, Toronto, outlining procedures and giving instructions for hard-facing steel with Haynes stellite.

*Rules.*—Lufkin Rule Company of Canada Limited, Windsor, Ont., have issued a 48-page booklet giving particulars of measuring tapes, tape-rules and rules for engineers and surveyors.

*Snow Removal.*—A 16-page bulletin of the Caterpillar Tractor Company, Peoria, Ill., illustrates various methods of snow removal utilizing tractors.

*Rotary Displacement Meters.*—A bulletin of 16 pages has been issued by the Roots-Connersville Blower Corporation, Connersville, Ind., describing general operating principles of meters. The standard meter may be utilized for line pressures up to 25 lb., the high pressure type up to 125 lb., and meters of special construction for pressures up to 300 lb.

*Drills and Breakers.*—The Independent Pneumatic Tool Company of Chicago describe, in a 6-page booklet, the Thor line of rock drills, paving breakers, clay diggers, sump pumps and accessories.

*Tractors.*—A 28-page booklet by the Cleveland Tractor Company, Cleveland, Ohio, illustrates some of the features of their tractors.

*Steel Sheet Piling.*—A circular of 4 pages has been received from the Canadian Sheet Piling Company Limited, Montreal. It gives design data used in the construction of cofferdams.

*Welded Piping.*—The Dominion Oxygen Company Limited, Toronto, in a 12-page circular, discuss some of the advantages of welded piping installations.

*Alloyed Cast Irons.*—A 20-page pamphlet of the International Nickel Company Inc., New York, gives data regarding the use of alloyed cast irons in petroleum refining equipment.

*Activities of the General Electric Company.*—An excellently illustrated 78-page brochure has been received from the General Electric Company, London, England. It contains a survey of the Company's organization and resources with some examples of recent installations.

### Errata

The following corrections should be made in the text of the paper on "The Characteristics and Quality of Nova Scotian Coals" by Dr. F. H. Sexton, published in the July number of The Journal, pages 524-532:

p. 529—Table IV—4th line—should read "4 Welsh anthracite 10.50 65.8 3.1"

p. 529—Table IV—8th line—should read "8 English coke 11.53 65.3 6.3"

p. 529—Table IV—9th line—should read "9 La Salle coke 10.08 75.8 7.1."

## RECENT ADDITIONS TO THE LIBRARY

**Proceedings, Transactions, etc.**

Institution of Civil Engineers: Vol. 240, pt. 2, 1934-35.

Institution of Civil Engineers: Engineering Abstracts No. 75, August 1937.

Institution of Municipal and County Engineers: The Year Book, 1937-38.

North-East Coast Institution of Engineers and Shipbuilders: Transactions, Vol. 53, Session 1936-37.

Royal Dublin Society: Economic Proceedings, Vol. 3, Nos. 3 and 4, August 1937; Scientific Proceedings, Vol. 121, n.s. Nos. 48-53, August 1937.

South Wales Institute of Engineers: Proceedings, Vol. 52, 1936.

**Reports, etc.**

*American Concrete Institute:* Properties of Cements and Concretes Containing Fly Ash, by Raymond E. Davis, Roy W. Carlson, J. W. Kelly and Harmer E. Davis. 1937.

*American Foundrymen's Association:* Foreman and Apprentice Training in Foundries, 1937.

*British Columbia, Department of Lands:* Annual Report of the Lands and Surveys Branches, 1936.

*British Standards Institution:* British Standard Glossary of Acoustical Terms and Definitions, March 1936.

*Canada, Department of Labour:* Labour Legislation in Canada, 1936.

*Canada, Department of Mines and Resources, Mines and Geology Branch:* Analyses of Coals and Other Solid Fuels, 1934 to 1936. The Canadian Mineral Industry in 1936.

*Canada, National Employment Commission:* Interim Report, 1st June 1936 to 30th June 1937.

*Canada, National Research Council:* 19th Annual Report, 1935-36.

*Canadian Government Purchasing Standards Committee:* Specifications for Petroleum Lubricating Oils; Aluminum Pigment for Paint (Type 1, Dry Powder); and Aluminum Pigment for Paint (Type 2, Paste); September 1937.

*Canadian Engineering Standards Association:* Standard Specification for Structural Timber, June 1937.

*Canadian Institute of Mining and Metallurgy:* The Co-operative Committee System of the Consolidated Mining and Smelting Company of Canada, Limited, by Selwyn G. Blaylock, C. W. Guillaume, H. Hanskin.

*Canadian Medical Association:* Prevention of Silicosis by Metallic Aluminum, by J. J. Denny, W. D. Robson, Dudley A. Irwin, 1937.

*Dominion Bridge Company, Limited:* A Dominion which Spans a Dominion, by Mrs. F. P. Shearwood.

*Electrochemical Society:* Preprints 72-6 to 72-13.
Electrochemical Protection of Iron from Corrosion in Alkalies, Composition of Some Complex Metallic Cyanides, Electrolytic Process in the Magnetic Field, Effect of the Speed of Rotation on the Electrode Potentials of Copper and Zinc, Standardization of the *pH* Scale, Thyratrons for Grid-Controlled Rectifier Service, Measurement of Direct Potentials Originating in Circuits of High Resistance, Theory and Phenomena of High Current Densities in Low Pressure Arcs.

*Ohio State University Studies, Engineering Series:* Thermodynamic Investigation of the Flash Evaporation of Concentrated Potassium Sulphate Liquor from Polyhalite, by J. P. Creag, J. H. Koffolt and J. R. Withrow. Vol. 6, No. 3, September 1937.

*U.S. Department of the Interior, Bureau of Mines:* Minerals Yearbook 1937. Review of Literature on Effects of Breathing Dusts with Special Reference to Silicosis, Bulletin 400. Asbestos, Bulletin 403. Relative Value of Gypsum and Anhydrite as Additions to Portland Cement, by Paul S. Roller and Murray Halwer, Technical Paper 578, 1937.

*U.S. War Department:* Annual Reports, Report of the Chief of Engineers U.S. Army, 2 vols., 1936.

*University of Illinois:* Bulletin 292, Tests of Steel Columns. Bulletin 293, The Combined Effect of Corrosion and Stress Concentration at Holes and Fillets in Steel Specimens Subjected to Reversed Torsional Stresses, by Thomas J. Dolan. Bulletin 294, Tests of Strength Properties of Chilled Car Wheels, by F. E. Richart, Rex L. Brown and Paul G. Jones. Bulletin 295, Tests of Thin Hemispherical Shells Subjected to Internal Hydrostatic Pressure, by Wilbur M. Wilson and Joseph Marin.

**Technical Books, etc.**

The Cracking Art in 1936, by Gustav Egloff and Emma E. Crandal; covering publications appearing in 1936. (*Universal Oil Products Company, Research Laboratories, Chicago, Ill.*)

Engineering Properties of Soil, by C. A. Hogentogler. 1937. (*McGraw-Hill Book Company, Inc.*)

Handbook of Chemistry, by Norbert Adolph Lange. 1937. (*Handbook Publishers, Inc., Sandusky, Ohio.*)

How To Make Alignment Charts, by Merrill G. VanVoorhis. 1937. (*McGraw-Hill Book Company Inc.*)

Petroleum Technology in 1936, by F. H. Garner. (*Presented by the Institution of Petroleum Technologists.*)

# BRANCH NEWS

## Niagara Peninsula Branch

*G. E. Griffiths, A.M.E.I.C., Secretary-Treasurer.*
*J. G. Welsh, S.E.I.C., Branch News Editor.*

On September 21st, 1937, the Niagara Peninsula Branch ushered in the 1937-38 season of activities with a highly instructive and entertaining dinner meeting at the Leonard hotel in St. Catharines. Following a few words by the Branch's new Chairman, L. C. McMurtry, A.M.E.I.C., in which the hearty co-operation of all was requested for the new Secretary-Treasurer, George E. Griffiths, A.M.E.I.C., A. McPhail, A.M.E.I.C., introduced Mr. P. B. MacEwen, combustion engineer of the Ethyl Gasoline Corporation.

Through the medium of motion pictures, Mr. MacEwen traced the research leading to the discovery of ethyl gasoline. First showing the development of the wheel, then the great discovery of potential energy of fire, resulting in the development of steam as a prime mover. Then came the internal combustion engine, and with the advent of the starter the automobile was deemed, by many, perfected. But in spite of all mechanical improvements, the engine retained its characteristic knock, so attention was turned to the fuel. It was almost immediately discovered that iodine bettered the condition, and finally tin and lead were found to be very effective in eliminating the knock as well as lowering the temperature on the cylinder walls. This led to the use of ethyl fluid. Ethyl fluid contains tetraethyl lead, ethylene dibromide, ethylene dichloride, and a dye for indication. Actual photographs were shown of the combustion in the cylinder head, having been secured by inserting a quartz window in the cylinder head. From these it was seen that under normal conditions the gas exploded with a blue flame travelling across the combustion chamber from the spark plug to the opposite cylinder wall, whereas under knocking conditions the flame was white, and there were two waves, one wave ignited by the spark plug, and another wave that shot back from the far cylinder wall, having been initiated by the high heat of compression generated by the primary wave. When these counter waves met, an explosion occurred resulting in the knock.

Mr. MacEwen then discussed the relationship of an engine to its fuel. Slides were shown comparing the properties of ethyl gasoline with ordinary gasoline, and with other explosive substances, the octane number being used to qualify the fuel. It was explained that the octane number was a measure of the anti-knock properties of the gasoline and that it was determined by matching the explosion pressures of a controlled mixture of iso octane and normal heptane to that of the gasoline, the percentage of iso octane being the octane number. The importance of the proper blending of the gasoline was emphasized. For starting, a light gasoline is required; for acceleration, a heavier grade, and for power, still heavier. Mr. MacEwen pointed out that there is no advantage in using a better fuel, if the spark is not advanced to permit the motorists to take advantage of the extra power available.

After a few remarks as to reduction in size of engines made possible by these improvements in fuel, the meeting resolved into a lively discussion. G. E. Hood, A.M.E.I.C., moved a vote of thanks to the speaker, which was heartily endorsed by those present.

## Saguenay Branch

*C. Miller, A.M.E.I.C., Secretary-Treasurer.*

The annual general meeting of the Saguenay Branch was held at Dolbeau on the afternoon of July 30th, 1937. About thirty members and guests were present.

After a very enjoyable luncheon at the Dolbeau Inn the meeting was called to order by F. L. Lawton, M.E.I.C., acting as chairman in the absence of S. J. Saunders, M.E.I.C.

The Secretary-Treasurer then presented the annual report. Moved by R. Rimmer, A.M.E.I.C., seconded by J. R. Hango, A.M.E.I.C., that the report be adopted as read.

The scrutineers' report on the election of officers for the Saguenay Branch Executive for the ensuing year was read; Chairman, F. L. Lawton, M.E.I.C., Vice-Chairman, M. G. Saunders, A.M.E.I.C., Secretary-Treasurer, C. Miller, A.M.E.I.C.

F. L. Lawton, M.E.I.C., then expressed the appreciation and thanks of the members of the Branch for the fine work done during the past season by the outgoing executive, and his appreciation of the honour bestowed in electing him Chairman for the coming year.

The Chairman then gave a brief resume of the Round Table Conference, and described the activities of the Semicentennial Meeting of The Engineering Institute of Canada held in Montreal. He stressed the importance of being able to speak with ease at such meetings and strongly urged the young men of the Branch to seize every opportunity of furthering their speaking ability.

G. H. Kirby, A.M.E.I.C., spoke briefly on the activities of The Institute, stressing the varied problems which are being dealt with day after day by engineers, and urging the younger members of the Branch to take an active interest in Branch affairs in order to benefit not only themselves but the engineering profession in general. Mr. Kirby then read a letter from Headquarters concerning the illuminated greetings sent to the Semicentennial celebrations by sister societies over the world, which were being passed from branch to branch to be displayed.

A. C. Johnston, A.M.E.I.C., suggested that the Secretary endeavour to obtain these greetings in order to display them at a future meeting.

Through the courtesy of A. G. Jacques, A.M.E.I.C., of the Lake St. John Power and Paper Company, Limited, the members were taken on an inspection tour of the mill, under the guidance of members of the staff who explained the process and operations step by step.

Following the trip through the mill, F. L. Lawton, M.E.I.C., expressed the thanks of all present for the courtesy shown the Branch by the Lake St. John Power and Paper Co., Limited, and for the very fine way in which the tour was conducted.

The meeting then adjourned to the Trappist Monastery where the members were conducted through the building and inspected the limestone quarry, following which the Chairman expressed the thanks of the members present to Father Samuel and Father Sebastien for their genial courtesy.

## Vancouver Branch

*T. V. Berry, A.M.E.I.C., Secretary-Treasurer.*

Forty-seven members and guests of the Vancouver Branch greeted President, G. J. Desbarats, C.M.G., Hon.M.E.I.C., at a luncheon held in his honour in the Georgian room of the Hudsons Bay Company's store on Wednesday, August 25th, 1937.

Seated at the head table with the President were Past-Presidents Hugh Walkem, M.E.I.C., and E. A. Cleveland, M.E.I.C., H. N. Macpherson, A.M.E.I.C., Chairman of the Vancouver Branch, P. H. Buchan, M.E.I.C., Councillor, A. Vilstrup, President of the Association of Professional Engineers of B.C., and E. A. Wheatley, M.E.I.C., Registrar of the Association, C. Arnett, President of the Vancouver Section of the A.I.E.E., and J. N. Finlayson, M.E.I.C., Dean of the Faculty of Applied Science of the University of British Columbia.

After luncheon Mr. Desbarats addressed the gathering on Institute matters. Speaking in a retrospective mood, he expressed the opinion that The Institute had accomplished much in its special sphere in its fifty years of activity. He was glad to observe, too, that The Institute was held in high regard by sister engineering societies in Great Britain, the United States and in other countries as was evidenced by the representation from these societies at the recent Semicentennial celebration and the expressions of goodwill and esteem received from them on that occasion.

Mr. Desbarats spoke of the relations of the Headquarters administration and the branches and outlined some of the difficulties which Council met due to the remoteness of some of the branches from Montreal. The speaker also referred to the recent ballot on the proposed amendments to The Institute's by-laws and commended the work of the Committee on Consolidation on their faithful work over many months prior to the ballot.

A vote of thanks to the speaker was proposed by Dean J. N. Finlayson and heartily endorsed by the meeting

## Victoria Branch

*Kenneth Reid, Jr.E.I.C., Secretary-Treasurer.*

An informal reception was held at the home of Mr. and Mrs. F. C. Reid, Victoria, B.C., on Friday evening, August 20th, 1937, in honour of G. J. Desbarats, Hon M.E.I.C., President of The Engineering Institute of Canada, and Mrs. Desbarats. This proved a most successful reception attended by over twenty-five members of the Victoria Branch and their wives. The President addressed the members briefly on Institute matters, outlining the work of the Committee on Consolidation, the results of the ballot, and the features of the recent Semicentennial celebration.

## Winnipeg Branch

*H. L. Briggs, A.M.E.I.C., Secretary-Treasurer.*

Summer activities of the Branch have included two luncheons to distinguished engineers from abroad who have been guests of The Institute at the Semicentennial celebrations, the first to Mr. Johnstone Wright, M.I.C.E., M.I.E.E., chief engineer of the Central Electricity Board, London, England, on June 8th, and the second to Brigadier-General Magnus Mowat, C.B.E., M.I.Mech.E., Secretary of the Institution of Mechanical Engineers, London, England., on July 12th.

Organized by Messrs. A. L. Cavanagh, A.M.E.I.C., and C. S. Landon, forty Winnipeg engineers and visitors took part in a golf tournament on August 9th at the Assiniboine Golf Club.

On August 30th, the Branch was honoured by the presence of President and Mrs. G. J. Desbarats at a dinner at the Motor Country Club, Lower Fort Garry.

President Desbarats addressed a general meeting of the membership on August 31st. He told of the outstanding success of the Semicentennial celebrations, outlined the steps which Council had taken to improve relationships with the Professional Associations by the formation of main and sub-committees on "Professional Interests," and described briefly his visits to the other western branches of The Institute.

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The Service is operated for the benefit of members of The Engineering Institute of Canada, and for industrial and other organizations employing technically trained men—without charge to either party.

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YOUNG CIVIL ENGINEER, B.Sc. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

CIVIL ENGINEER, B.Sc., M.Sc., R.P.E.; Lieut. C.E., R.O. 16 years municipal, highway and construction, 5 years overseas. Married. Read, write and talk French. Will go anywhere. Apply to Box No. 737-W.

RADIO AND ELECTRICAL ENGINEER, B.Sc., '31, Jr.E.I.C. Single. Age 30. One year and a half actual field experience in power and lighting equipment. Extensive work in telephone and radio layouts in switchboard and installation depts. Particularly interested and experienced in sales and traffic work in telephone and radio company. At present supervisor over sales and service of radio and electrical company. Available on short notice. Location immaterial. Apply to Box No. 740-W.

ELECTRICAL ENGINEER. Graduate, age 34, single, with thirteen years experience in industrial electrical and mechanical work, also experienced in heating, ventilation, air conditioning and refrigeration. Now employed. Montreal preferred. Apply to Box No. 795-W.

CIVIL ENGINEER, S.E.I.C., B.Sc. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman. compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

MECHANICAL ENGINEER, Jr.E.I.C., technical graduate, bilingual, age 35, married, experience includes five years with firm of consulting engineers, design of steam boiler plants, mechanical equipment of buildings, heating, ventilating, air conditioning, plumbing, writing specifications, etc. Five years with large company on sales and design of power plant, steam specialties and heating equipment. Available on short notice. Apply to Box No. 850-W.

STRUCTURAL ENGINEER, B.A.Sc., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

ELECTRICAL ENGINEER, B.Sc. (McGill '28), age 34. Experience includes transmission line and rural distribution construction and design. Some installation of motors and equipment, also house wiring. Available immediately. Apply to Box No. 940-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.

ELECTRICAL ENGINEER AND GEOPHYSICIST. B.Sc. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

### Situations Wanted

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CONSTRUCTION SUPERINTENDENT, M.E.I.C. Age 49. Married. Twenty-two years experience as engineer, superintendent and manager in charge of hydro-electric, mechanical production, structural steel erection, also considerable experience in steam plants, combustion, transmission lines, millwright work, complete mine installstions, rock work, rock crushers and conveyors. Executive ability. Speaking French fluently. Location immaterial. Apply to Box No. 1482-W.

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ELECTRICAL ENGINEER, B.Sc. '31 (Univ. of Alta.), Jr.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work. location immaterial and available at once. Apply to Box No. 1522-W.

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## Contents



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# The Fatigue of Metals

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**Paper presented before the Aeronautical Section of the Ottawa Branch of The Engineering Institute of Canada, April 6th, 1937.**

**SUMMARY:—A concise account of present knowledge as to the failure of metallic materials under alternating stresses, with notes on behaviour of crystals under stress, strain-hardening, and various methods of testing. Suggestions for routine tests on machine parts are given.**

Although "progressive failure" has been suggested as being a more truly descriptive phrase, custom has decreed that the somewhat vague and misleading term, "fatigue," should be used in describing the failure of materials under alternating stresses.

The endurance limit of a material is a measure of its ability to resist these alternating stresses and may be defined as the unit stress the material can stand for an indefinite number of stress cycles without failure resulting. The algebraic difference between the maximum and minimum stress in the cycle is referred to as the range of stress. The term "range ratio" is also used to indicate the range of stress. The range ratio is the algebraic ratio between the minimum and maximum stresses. A ratio of $-1$, for instance, indicates a completely reversed cycle through a mean stress of zero. The endurance limit varies with the type and range of stress and also with the temperature.

In designing structures, such as bridges, which are subject to fairly constant static stresses on which relatively unimportant cyclic stresses are superimposed, it is only necessary to know a material's ability to resist static stress. However, machine parts such as axles, shafts, gear teeth, connecting rods, etc., are subject mainly to alternating stresses and in these cases it is essential that the designer know what performance may be expected from his constructional materials under such alternating stresses. The high working stresses and speeds involved in aircraft parts make the problem of fatigue one of particular importance to the aeronautical engineer.

In spite of the importance of the subject, however, certain misconceptions as to the nature of the mechanism of fatigue failure still exist. Failure under alternating stresses is still referred to as failure by crystallization in spite of microscopic and X-ray evidence that the metal is just as definitely crystalline before being stressed as it is at the time of failure. There is also an impression, due to the unfortunate use of the word "fatigue," that a metal becomes "tired" and that the failure is associated with metal weariness, a weariness that can be cured by a resting of the material.

To obtain any understanding of the mechanics of fatigue failure the problem must be approached fundamentally, for the properties of metals and alloys must be related to their inner atomic structure. For this reason, no apology is given for introducing the subject of atomic physics.

In the final analysis, the strength of a material depends on the strength of its atomic bonds. Generally speaking, there are three types of atomic binding: the ionic, as in common salt, where electrons of opposite sign combine atoms; the homopolar, as in organic materials, where an electron is shared by atoms; and the metallic, where atoms are held together by positive electrons through what has been postulated as the interaction of electron gas. The problem of the nature of atomic cohesion is very complicated, however, and belongs to the field of the mathematical physicist. The metallurgist can only reduce the problem to a point where wave mechanics can be applied.

Metallic materials as a rule consist of a mass of very small irregularly oriented crystals separated by boundaries of irregular shape. Within the crystals the atoms are arranged in regular lattice forms. The crystal is made up of blocks of these perfectly formed atomic units, each block shifted slightly in relation to a neighbouring block. The nature of the material at the grain boundaries is debatable, for the various crystals are oriented differently and some adjustment must occur at these boundaries. It has been suggested that crystals are broken at the boundaries into small "crystallites" each oriented somewhat differently, the atomic bonds of the various crystallites being in a strained condition owing to this difference in orientation.

Most common metals have their atoms arranged in three definite orders: the body centred cubic, the face centred cubic, and the close-packed hexagonal.

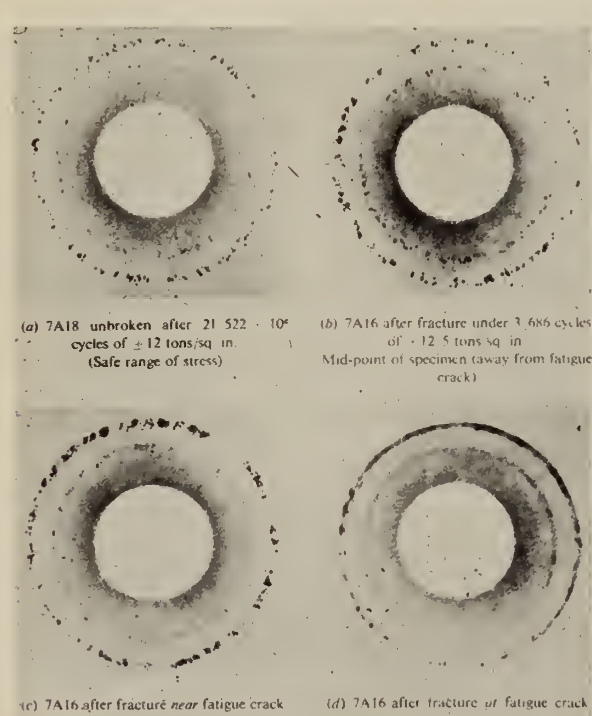
In order to correlate the physical properties of metals with crystal structure and so to reduce the problem to one of interatomic attraction, tests have been made on single crystals. Several methods can be employed in making single crystal test pieces. Test pieces containing two or more crystals can also be made, in which the effect of the crystal boundary may be studied. The research work of Dr. H. J. Gough, of the National Physical Laboratory, Teddington, England, on the fatigue properties of large crystals has been outstanding and he has added greatly to our understanding of fatigue failures.

Now it has been established, by an investigation of the behaviour of single crystals under static load, that deformation can occur either by what is known as slip, or by twinning, or by a combination of the two. "Slip" involves a shearing along certain crystallographic planes. In "twinning," two parts of a crystal are rotated about a common twinning axis. In general, these investigations showed that slip occurred along a direction containing the greatest number of atoms and on a plane parallel to planes having an equal or greater atomic density than any other plane containing the same slip direction.

Gough desired to obtain information on the mechanics of fatigue failure. His method of testing was as follows: The orientation of the longitudinal axis of the test specimen with respect to the crystallographic axes was first determined by the X-ray method. The specimen was then carefully polished and tested under reversed torsional stresses, a system of stressing which caused very little distortion at fracture and hence simulated fatigue failures encountered in service. At various intervals in the test, a microscopic examination of the surface of the test piece was made. It was discovered that slip bands formed on the surface of the metal.

These slip bands represent microscopic unevenness in the surface and can be removed by polishing. After each examination the specimens were repolished. By relating the position of these slip bands to the crystallographic axis of the fatigue specimen, Gough proved that the mechanism of slip was the same under alternating stresses as it was under static loading. Furthermore, he found that these slip bands formed rapidly at first, then less rapidly, and then finally ceased to form if no fracture occurred. Under an unsafe range of stress, however, these slip bands were still being produced when failure occurred. At loads very near the fatigue limit, fracture was found to occur after slip bands ceased to form. In every case the fatigue crack appeared at the most heavily formed slip band, although its subsequent propagation was influenced by the direction of the maximum nominal stress.

Additional tests by Gough on specimens containing two or more crystals revealed that crystal boundaries have very little effect on the fatigue mechanism, for each crystal



(*a*) 7A18 unbroken after 21 522 · 10⁶ cycles of ± 12 tons/sq in. (Safe range of stress)

(*b*) 7A16 after fracture under 3,686 cycles of ± 12.5 tons/sq in. Mid-point of specimen (away from fatigue crack)

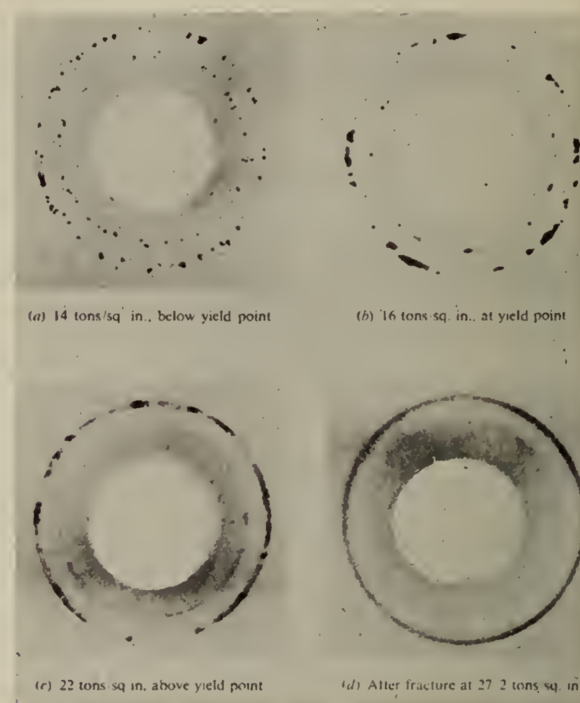
(*c*) 7A16 after fracture *near* fatigue crack

(*d*) 7A16 after fracture *at* fatigue crack

**Fig. 1—X-ray patterns showing crystal breakdown.**

acted as if it were a separate single crystal specimen, the slip bands changing direction at the boundary. In no case was intercrystalline failure found. It was concluded that the increased strength of a finer-grained aggregate was probably due to the fact that its crystals have a greater variety of orientation, with the result that deformation was more general. It was also thought possible that slip was restrained to some degree at the boundary.

Corrosive atmospheres lower the resistance of materials to alternating stress. Gough found that a specimen tested under corrosive conditions corroded very rapidly in the vicinity of the slip band, while specimens subjected to similar corrosion attack prior to being tested under atmospheric conditions pitted badly but exhibited practically the same fatigue resistance as did uncorroded test specimens. Gough therefore concluded that the low corrosion fatigue strength of materials was due to an accelerated corrosion action occurring locally in heavily strained regions.



(*a*) 14 tons/sq in., below yield point

(*b*) 16 tons sq. in., at yield point

(*c*) 22 tons sq in. above yield point

(*d*) After fracture at 27.2 tons sq. in.

**Fig. 2—X-ray patterns showing crystal breakdown.**

Gough, then, has shown that the nature of fatigue failure in specimens of more than one crystal is similar to that occurring in single-crystal specimens; that corrosion fatigue is merely a special type of fatigue failure; and that the mechanism of fatigue failure is similar to that involved in static failures, the only difference being that the action is one of local strain hardening produced by slip on favourably oriented planes in the first case and general strain hardening in the second. Strain hardening, it is thought, is brought about as a result of a straining of atomic bonds between small crystallites, the product of crystal breakdown, which are rotated with relation to one another. When this rotation of crystallites is sufficiently great a rupture of atomic bonds takes place and failure occurs. Stress alternation causes strain and hence rotation of the crystallites. It is assumed, when specimens are under a safe range of stress, that atoms in neighbouring crystallites are in equilibrium and reverse from one position to another without a straining of atomic bonds. Instead of being stored within the metal the energy of reversal is dissipated as heat.

Figures 1 and 2 offer experimental substantiation of this hypothesis.

These have been taken from a paper by Gough and Wood which appeared in Volume 154, Proceedings of the Royal Society, May 1936.

The spots on the rings represent reflections from individual crystals. Small crystallites produce solid rings; large crystals, spots. The breaking down of crystals can thus be followed by the changing nature of the X-ray pattern. The pattern in the upper left of Fig. 1 shows that the fatigue specimen is not greatly affected within a safe range of stress. The other three patterns illustrate the local nature of the fatigue fracture and show the extent of the crystal breakdown at the point of fracture.

Figure 2 shows spectrograms taken from a specimen submitted to static stress. It may be seen that the patterns are very similar to those obtained from a specimen broken by reversing stresses.

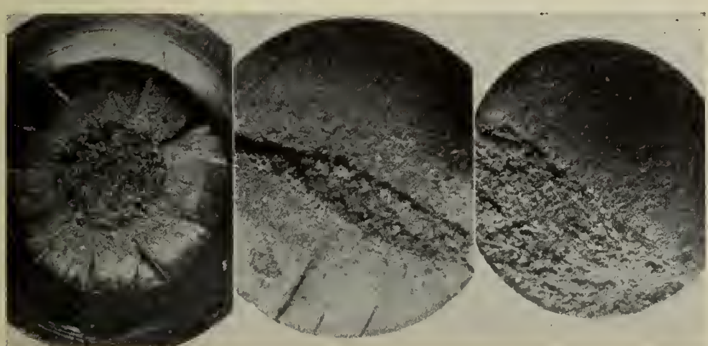
The real reason for slip and the nature of atomic bonds still remains to be solved. It is probably well said that the scientist solves problems by inventing bigger ones.

Machines have been designed for testing specimens under reversed axial, torsion and bending stresses, and under combinations of these stresses. The specimen is usually rotated or the stresses applied by means of an electric motor, an automatic count being kept of the number of rotations or reversals.

Machines are also used in which the test specimen is vibrated at its calculated natural frequency between the poles of a magnet. The vibrational speed is controlled by a radio valve, the frequency of vibration being measured by a stoboscope. Values given by these machines are 15 per cent below Wohler values but are claimed to be nearer the true result because of the use of a natural vibrational frequency.

The fatigue test specimens must be very carefully polished, for scratches result in stress concentration. It should also be remembered that the fatigue limit of a material varies with the type and range of stress. There is also reason to believe that the fatigue strength of large members is not proportionally as great as that of smaller parts. The testing method, then, should if possible approximate service conditions. However, valuable information can be obtained by the simple rotating beam test on small specimens.

The usual practice in making endurance tests is to load the specimen at about 60 per cent of its tensile strength and then progressively reduce the loading until a specimen runs for a large number of reversals without failure. A new test specimen is used for each load. The number of reversals of stress required before it can be concluded that no failure will occur after an infinite number of reversals is five million for wrought ferrous materials, ten million



(*a*) (*b*) (*c*)

**Fig. 3—Fractures produced by reversed bending.**

for cast ferrous materials, and fifty million for non-ferrous materials.

Various fast methods of endurance testing have been suggested. One of these methods measures the temperature changes in a specimen, another the strain. Although in some cases valuable results can be obtained, the general opinion appears to be that these methods are not to be relied upon. High speed machines have recently been made which reduce the time of testing. The speed appears to have little effect on the fatigue strength up to five thousand revolutions per minute. Above this limit, however, the endurance limit is somewhat raised.

The fatigue limit of ferrous material is from 40 to 50 per cent of the ultimate strength. No general relationship has been established for non-ferrous materials. An approximation can be obtained for the fatigue strength of ferrous material by multiplying the Brinell hardness by 250. The relationships stated, however, are only approximate, and for definite information fatigue tests should be conducted.

Fatigue failures can often be identified from the type of fracture. One of the features of fatigue failure is the


**Fig. 4—(above)—A fracture produced by static torsion. (below)—A fracture produced by reversed torsion.**

absence of distortion at the point of fracture, because under fatigue conditions a specimen is strained alternately through a mean position, while the strain under static conditions is in one direction. The result is an absence of distortion in the former case and marked distortion in the latter.

Failures by impact as a result of brittleness are also characterized by a lack of deformation. The fatigue fracture, however, has other peculiarities in addition to its freedom from marked distortion.

Three fractures are shown in Fig. 3 which occurred under reversed flexure. All are characterized by fine and coarse areas. The fine area represents the fatigue fracture and owes its fineness to the wearing caused by the repeated opening and closing of the crack. Failure occurred suddenly across the coarsely crystalline section. In (*a*) the fatigue crack worked in from all sides; in (*b*), from two directions; and in (*c*), from the top only. Under torsion the longitudinal shearing stress is as great as the transverse shearing stress, with the result sometimes that a star-shaped fracture is formed, failures occurring along different directions.

Figure 4 shows some torsion fractures, the upper produced by static torsion, the lower by alternating torsional stresses. The dark areas in the lower figure reveal the position of the fatigue crack. There are no coarsely crystalline areas in this instance, because the steel tested was a fine-grained material.

A failure under repeated axial stressing is shown in Fig. 5. Fine and coarse areas may be seen, but the fractur differs from that produced by bending in that these areas are not separated into distinct zones. The origin of the fatigue crack can sometimes be located by an examination of the fracture, as may be seen in Fig. 6 where the commencement of failure is outlined by a series of concentric circles.

In some cases an inspection may locate fatigue cracks before failure occurs. Fatigue cracks are usually too fine to be located by eye, and a microscopic examination is much too tedious. X-ray and gamma-ray detection methods are employed, but these are expensive and considerable experience is needed in interpreting the negatives. They are, however, valuable where members must be inspected in position. The surface to be examined is sometimes coated with oil. The excess oil is then removed and a coating of whiting and wood alcohol applied. Minute cracks retain oil which can be forced out by hitting the article with a hammer. The white coating shows up the oil streaks. A patented magnetic method of crack detection is also used. The articles are coated with a magnetic material, such as magnetic oxide of iron, and magnetized in two directions. Poles are formed where cracks occur and these collect the magnetic particles.

The National Carbon Company reports that cracks can be located by wetting the article in a solution of anthracene and carbon tetrachloride and then inspecting under ultra-violet light. The cracks are said to become phosphorescent.

The majority of machine part failures are undoubtedly of a fatigue nature. Some occur because designers do not make sufficient allowance for the effect of alternating stress, and some because the material is roughly handled and notched in fabrication. Before the days of high tensile steels, the custom was to design from the yield point, allowing a liberal factor of safety. Alternating stress was thus provided against, for the fatigue strength of the lower-strength materials bears nearly the same relationship to the alternate stress as does the yield point.

**Fig. 5—Fracture produced by reversed axial stress.**

This is not the case, however, for high-elastic-limit alloy material, and members made from this material must be designed from fatigue strength data.

Where such an expense is warranted, full-size specimens should be tested under stresses likely to be encountered in service. Failing this, the fatigue stress of the constructional material should be accurately determined from standard-size specimens and the values so obtained should be used in the designing of all parts likely to be subjected to alternating stresses. When using these data, however, it must be remembered that they have been obtained from highly polished specimens. The tests show up the effect of internal stress raisers, such as inclusions, etc., but do not take into consideration the effect of external imperfections which are sure to exist in machine parts. Some materials are more sensitive to these defects than others. In general, low-strength materials like mild steel are less "notch sensitive" than high-strength alloyed steels because they are more subject to plastic deformation which reduces stress concentration at the notches. The tendency

**Fig. 6—Showing origin of fatigue failure, outlined by concentric circles.**

toward plastic deformation also enables the weaker materials to better withstand occasional overstress. When notches are unavoidable, then, it is sometimes better to use the lower-fatigue-limit material rather than the high-elastic-limit high-fatigue-limit alloy steel. In any case, this latter material should always be given a good finish. A damping test developed by Dr. O. Foeppl, in Germany, for evaluating the property of notch sensitivity, would appear to deserve more attention than it has received to date.

The condition of the surface material is also important, especially when the member is subjected to reversed bending stresses. Carburizing and nitriding increase the fatigue strength, while a surface decarburization reduces the resistance to alternating stresses.

A well-designed part is useless, however, if made from poor material, consequently each metal shipment should be tested before being formed.

The following routine tests have been suggested: A tensile test, which reveals the ductility of the material; a single-blow impact test, which determines the shock-resisting properties of the material; and a proof stress fatigue test. In this last test the fatigue strength is estimated from the ultimate strength, for the relationship of the fatigue strength with the breaking stress is usually known. The specimen is then loaded at a ton per square inch below this limit and given five million reversals. If no fracture occurs the material can be passed. Even with a high speed rotating beam machine, however, this test would be fairly long and costly and would only be justified under special conditions.

Figures 3 and 5 of this paper were taken from the book, "Fatigue of Metals," by H. F. Moore and J. B. Kommers; Fig. 6 appeared in H. J. Gough's book, "Fatigue of Metals"; and Fig. 4 in a paper, "The Physical Properties of Axle Shafts," by H. B. Knowlton, which was published in the March 1937 number of the Transactions of the American Society for Metals.

# The Beet Sugar Factory at Picture Butte, Alberta

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*Chief Engineer, Canadian Sugar Factories Ltd., and B.C. Sugar Refining Company, Ltd.*

**Paper presented before the Calgary Branch of The Engineering Institute of Canada, March 4th, 1937.**

**SUMMARY.—Includes reasons for choice of site, preliminary work and the construction of a beet sugar factory. A brief description is included of buildings, equipment and method of handling beets from the raw to the refined product.**

In building a beet sugar factory the first consideration is the selection of the site. The factory must be located on a railroad where the principal raw materials—beets, coal and limerock—are available at reasonable freight rates.

After the above requirements have been satisfied, it is desirable to select a site having the following characteristics:—

1. A good water supply.
2. Provision for waste water disposal.
3. Ground sloping in the right direction in reference to the railroad tracks and highways.
4. Soil suitable to sustain a load of 2 tons or more per square foot.
5. An economical supply of sand and gravel for concrete and for road building.
6. Size and shape suitable for the factory design and yard plans.

The selection of the site in this instance was quite simple as the Lethbridge Northern Irrigation District has a fund of reliable information such as aerial photographic surveys and topographic maps. The District also determined where reservoirs could be economically located. The site at Picture Butte was finally decided upon as best suited to meet all requirements.

### Preliminary Work

A topographic map was made by taking elevations at the intersection of parallel lines 25 ft. apart running north and south and east and west. From these data the exact location of the buildings, beet storage and pulp silo was decided upon. Plans were then made and the work started.

Temporary buildings consisting of bunk house, mess hall and office were started May 13th, 1935.

A gravel plant was built on the banks of the Old Man river three miles away and consisted of a belt conveyor, elevator, crusher, rotary screen, grizzly bar screen, sand washing box and bins. The capacity of the plant was 75 to 100 cu. yd. per day.

Soil tests were made in the usual manner by placing weight on a platform supported by a post exactly 12 in. square. Thirty-six hours after the application of 4,000 lb., equivalent to 2 tons per sq. ft., the post had settled 7/32 of an inch. This result was considered satisfactory for the load of 2 tons per sq. ft., and the foundations were designed accordingly.

To carry out a job of this nature in an economical manner, it is necessary to have a complete set of detailed plans and drawings. A considerable portion of this work was carried on in the Vancouver office which also acted as a clearing house for all information, and supervised all phases of the work. All plans, specifications and drawings were checked and approved before being sent to the field at Picture Butte for use in construction.

The Canadian Pacific Railway spur track was started about June 1st, 1935, and sufficiently completed so that six cars of lumber and piles could be received on June 8th.

### General Methods of Construction

Tracks were run through and alongside the locations for the buildings. A ramp was built along side a construction track for dumping the sand and gravel trucks into stock piles. The locomotive crane filled the elevated gravel and sand bins direct from these stock piles. These bins discharged direct to the concrete mixers.

The use of locomotive cranes permits economical construction. Two were used: one 25 ton crane with a 75 ft. boom and one 20 ton crane with a 50 ft. boom. Practically all of the structural steel and machinery were set in place by these cranes. The crystallizers, constituting one of the heaviest pieces and weighing 15 tons each, were lifted into position on the third floor by the large crane. A wooden pole was lashed to the end of the 75 ft. boom of the large crane and used for the erection of the highest structural steel and tanks.

In order to properly carry out the erection with one of the crane tracks going down the centre of the building, it was necessary to carefully schedule the delivery of the structural steel and machinery. We started at the east or beet end of the main building and backed up as erection progressed. Permanent tracks along the west side of the warehouse and east side of the boiler house and lime house, and the construction track south of the main building permitted access for locomotive crane work to practically all parts of the main building group.

Most of the work of excavation and moving of earth for the pulp silo, beet sheds, foundations, main water line and waste water tile line was either done with our locomotive cranes or carried out on a rental or contract basis employing such equipment as the Le Tourneau 10 yd. dirt mover, or power Fresno, crawler shovels, hoe and drag line.

### Type of Buildings

A reinforced concrete structure similar to concrete grain elevators was built for the bulk storage of sugar. This structure consists of six bins 33 ft. inside diameter by 85 ft. high inside arranged in two rows of three bins each.

The space between the large bins forms two additional bins called star bins.

On account of the heavy load, the bin foundations are carried on 752 piles, each pile being good for a load of 15 to 20 tons.

The six bin cylinders are all carried up simultaneously by means of moving forms, the pouring operation being carried on continuously 24 hours per day until finished. In our case the bin walls were carried up the 85 ft. from floor slab to roof in 161 hours. The cylindrical bins are lined with two layers of 7/16 by 3½ in. fir on 1¾ in. square studding, thus an air space is formed between the concrete and wood lining. The fir lining is laid in a horizontal position and fastened to the studding with galvanized nails. A waxed paper lining is placed between the two layers of fir. The sugar to and from the bins is all handled mechanically and is not touched by hand. The total capacity of these bins is about 240,000 one hundred pound bags, or 24,000,000 lb.

The other buildings, consisting of the main building, office, packing house, boiler house, power house, machine shop and storeroom, and warehouse, are built of concrete, steel and brick. The kiln house has corrugated galvanized iron siding above the second floor.

From the second floor up all brick walls are supported on steel.

As previously mentioned, foundations and column footings are designed for a soil pressure of two tons per square foot.

The steel is designed for a maximum stress of 16,000 lb. per sq. in. to allow ample strength for future changes or additions to the load.

Copper bearing steel sash was used throughout and that portion subject to moist air was galvanized. One-quarter inch wired glass was used throughout to reduce the fire hazard and maintenance.

Roofing is made of compressed asbestos, and Portland cement was also used for ultimate economy and for its fireproof qualities. As this type of roof sweats readily in cold climates, it was laid over 2 in. wood planks in locations where the air is moist.

All floors were treated with two coats of silicate of soda to reduce wear and particularly deterioration where subject to the acid action of sugar liquors.

The grouping of the buildings was carefully studied and plans made so that all buildings are connected together. At the same time provision is made for expansion, if ever necessary. A novel feature in the design is a gravel road encircling the main building group, giving truck as well as rail service wherever required.

### Boiler Plant

Two 707 hp. Stirling type boilers of the latest design were installed in the boiler house. These boilers are equipped with forced draft chain grate stokers, forced and induced draft fans, automatic soot blowers, superheaters, water cooled bridge walls, side wall cooling boxes, feed water regulators, boiler meters giving the steam flow, air flow and flue gas temperature, and automatic balanced draft and steam pressure control. The boilers produce steam at 250 lb. gauge and 140 deg. F. superheat. About one rated boiler horse power is installed per ton of beets sliced per 24 hours.

During a typical week the boilers operated at 174.5 per cent of rating which is equivalent to developing an average of 2,470 boiler hp. The boiler horse power developed this week per ton of beets sliced per 24 hours is 1.82, and per 100 lb. bag of sugar is 0.574.

**Fig. 1—Front of sugar factory with a sugar beet field in the foreground.**

The two steel stacks are supported directly on top of the two induced draft fans.

A novel feature of the design is the arrangement for operating one boiler at 300 per cent of rating in case the other boiler is out of service. When operating up to 200 per cent of rating the forced draft fan motors operate at 870 r.p.m. For ratings above 200 per cent the same motor operates at 1,160 r.p.m. The two induced draft fans are provided with three motors. Two of the motors will operate the two fans at 570 r.p.m. and the other motor can be used to operate either fan at 870 r.p.m. for ratings above 200 per cent.

The automatic boiler control maintains a slight vacuum in the combustion chamber at all times and controls the steam pressure. This instrument also maintains an equal distribution of the load between the two boilers. Electric motors operated through relays operate the dampers in this control system.

**Fig. 2—Rear of factory, in foreground edge of pulp silo with pipe supply line and beet piler.**

The overall continuous efficiency of the boilers is about 73 per cent. On account of the reasonable fuel cost due to our proximity to the coal mines, air pre-heaters would not pay a reasonable return on the investment.

The chain grate stokers discharge the ash continuously into a flume at the back of the boilers. A manganese steel lined pump connected to the flume discharges the ashes through a six inch pipe line into the waste water system.

The coal is elevated from a railroad car to the coal bunkers above the stoker hoppers with our locomotive crane. Each bin holds about one car of coal. The coal is continuously fed into the stoker hoppers through an oscillating chute equipped with magnets. These magnets are essential as they daily remove several pieces of tramp iron which might damage the stokers.

### Power Plant and Electrification

A 1,250 kilowatt steam turbine provides electric power at 480 volts, 3 phase, 60 cycles suitable for our 440 volt motors. The lighting system is 230-115 volt, 3 wire.

The entire plant is electrified except for the $CO_2$ compressor which is direct connected to a steam turbine. There are no steam cylinders, therefore no oil is present in the condensate or boiler feed water.

The actual load on the generator is about 750 kw. or 0.55 kw. per ton of beets sliced per 24 hours.

High speed motors carefully selected as to size resulted in a power factor of 82 per cent.

Flat belting has been nearly eliminated. Most of the machinery is either direct connected or driven through worm gear reducers which in turn are direct connected to the machine or drive the machine through roller chain drives. All pumps are direct connected except the sand pump. The balance of the drives are through V belts. This design permits the use of high speed motors with resulting economy in first cost and low maintenance.

### Beet Sugar Machinery

Most of the machinery is of the conventional design and standard in up-to-date plants. Some of the novel features in the design are as follows:

A beet feeder in main flume which regulates the flow of beets at the desired rate. This feature permits the use of a smaller beet wheel and beet elevator and increases the efficiency of the beet washer, roller table and picking table. The power requirements are also reduced. The following motors will easily handle the machines at a 1,500 ton slicing rate:

| | | |
|---|---|---|
| Beet wheel | 5 | hp. |
| Beet washer | 15 | hp. |
| Beet elevator | 7½ | hp. |

*Weightometer:* The sliced beets or cossettes are weighed on a weightometer as they travel on a belt from the cutters to the chute to the diffusion battery.

*Diffusion Battery Control:* The battery draft is controlled by a meter operated indicating dial. The meter is on the battery water supply line. This system is similar to that developed by the Swedish engineer, Mr. Nils Weibull.

*Calandria Pans:* All sugar is boiled in calandria pans of special design with low pressure steam, either first vapour at a pressure of 10 lb. per sq. in. (gauge) or exhaust steam at 22 lb. per sq. in.

*Thermo Compressor:* This machine is used to increase the steam economy and reduce the capital cost of evaporators. This device uses 292 lb. of live steam per minute at a pressure of 225 lb. per sq. in (gauge), and 140 deg. F. superheat to compress 243 lb. of first vapour at 10 lb. per sq. in. (gauge) into exhaust steam at 22 lb. per sq. in. (gauge).

*Bulk Storage Bins:* Four beet sugar factories in North America at this writing are using this method for storing sugar in concrete bins similar to grain elevators. The method was developed by the Great Western Sugar Company.

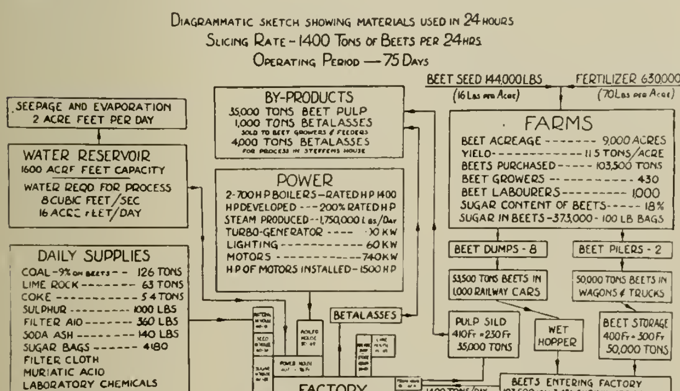


**Fig. 3—Materials used in 24 hours in beet sugar factory.**

*Pipe Design:* All piping 3 in. and larger have welded joints. Steel welding tees, ells, flanges, etc., are used in this design. The high pressure steam line has the Vanstone type of joint with cast steel fittings.

*Pumps:* The plant is equipped with 35 pumps which operate at 3,500 r.p.m., out of a total of 62 centrifugal pumps.

### Water Supply

The plant is supplied with water from a reservoir having 1,300 acre feet capacity, built for the use of the plant by the Lethbridge Northern Irrigation District. The reservoir is filled from Keho Lake through an irrigation canal.

The water is conveyed from the reservoir to the main water pumps in the power plant through a 20 in. i.d. wood stave pipe 3,224 ft. long. This pipe is double wrapped with asphalt impregnated burlap. As the pipe is buried six feet deep and kept full of water the year round, a long life is expected. There is a stand pipe at the lower end of the line to take the surge when the flow of water is interrupted.

**Fig. 4—View from top of bulk storage bins showing 42,000 tons storage pile of beets.**

The plant uses about 3,100 U.S. gal. per min. A like amount of water may easily disappear from the reservoir when strong west winds are blowing.

The water is pumped by centrifugal pumps to the main water tank on the fifth floor, sugar end, and distributed from there principally to barometric condensers. The warm water from the condensers is used for fluming beets and in the different processes.

### Beet Storage and Transporting System

About 42,000 tons of beets are stored on the storage ground over flumes on 45 ft. centres. This pile of beets is about 300 by 400 by 18 ft. deep. The beets are put into storage by means of two Hartburg pilers built at the Vancouver refinery shops of the company. These two pilers move parallel to the flumes, and handle up to 2,400 tons or more per 12 hour day.

Car beets are received over the wet hopper. The car of beets is dumped into this hopper and water flumes them into the plant as required. When the beets are frozen in the car a series of hoses distribute warm water over them to thaw them out before dumping. If not frozen too hard, 45 per cent of the beets in storage are worked into the flumes by two men. The balance is transferred from the pile to the flumes by a gas shovel. The flumes are all built on a grade of 1⅛ per cent on tangents and 1¼ per cent on curves. All flumes are equipped with overflow flumes or a space screened off from the beets where water can flow without obstruction, and turn back into the flume when past the blockade of beets. No beet signal whistle is provided as it is only necessary to dump beets into the flume as fast as taken away by the water.

The flumes under the beets in storage are built of cedar, the balance of the flumes being of reinforced concrete. The bottom of the concrete flumes are built on an 8 in. radius and are 20 in. wide at the top. The wood flumes have a flat bottom 16 in. wide and are also 20 in. wide at the top. All flumes under the storage pile are equipped with water tight gates to prevent warm water from backing up under the beets and causing deterioration in storage. A waste water connection and valve assures that all water can be drained out of the flumes above the gates.

After the beets are flumed into the factory a beet wheel lifts them out of the flume allowing the water alone to pass to the 24 in. tile line. The water from the flumes accounts for about 80 per cent of the total waste water. This 24 in. tile line runs a distance of 1,250 ft. and discharges into a coulee. The tile is laid on a grade of 3 ft. per 1,000.

The exhausted cossettes known as pulp are pumped out through an 8 in. overhead line 800 ft. long to the pulp silo. The silo is 300 ft. long by 200 ft. wide and will take care of 35,000 tons of pulp.

General Remarks

The plant was finished October 5th, 1936, and started manufacturing sugar on that date.

The total cost of the project is approximately $1,500,000, including 12 brick residences for employees.

Some $500,000 worth of machinery and supplies were purchased in Alberta, of which over $200,000 worth of machinery and steel was manufactured or fabricated in Calgary. About $300,000 was distributed in Picture Butte, Alberta, for labour.

On account of the difficulty of carrying out construction work during the Alberta winters, construction extended over a period of 17 months from May 1935 through September 1936. Up to April 1936 the number of employees employed on construction averaged 90. From that date to September 26th, 1936, the average was 240. The peak of activity extended for a period of five weeks from July 4th to August 8th, 1936, when the number of employees averaged 308.

One cannot emphasize too strongly that the success attained in building a project of this kind depends largely on the team work of the various units rather than on any grandstand plays. The purchasing, engineering, accounting and executive departments, the construction superintendent and the construction engineer were all members of that team. The construction superintendent and the construction engineer who were in charge of the work in the field carried on their part of the job in a very efficient manner.

The president of the company is keenly interested in having modern plants of the highest efficiency and his constructive attitude on the most modern equipment was an important factor in the up-to-date design adopted for Picture Butte.

The Company's total sugar production in Alberta during the past season was 652,996 one hundred pound bags.

The yearly consumption of the entire province is about 580,000 one hundred pound bags. The city of Calgary still uses about 40 per cent cane sugar, and as sugar producing capacity in this province is not justified unless the sugar can be sold, why not use more beet sugar and help a home industry?

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# Development of Radio Communication in the Bush

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**Paper presented at a meeting of the Junior Section, Montreal Branch of The Engineering Institute of Canada, November 16th, 1936.**

**SUMMARY.—Describes the development of communication in the bush with reference to fire protection, the advantages of radio, the improvements in equipment since 1929, some of the operating difficulties encountered and the desirability of employing a competent technical staff.**

The forests of Canada are one of the country's largest natural resources and the protection of these forests is a large and important business. Fire protection service calls for a reliable means of communication since it is only by rapid delivery of information concerning fires and orders for directing fire-fighting that the service can operate efficiently. In undeveloped country, the single-wire grounded-type telephone line has always been used since it is only necessary to string one wire through the bush, the ground serving as the return lead.

The Laurentian Forest Protection Association handles a considerable amount of fire-ranging in the Province of Quebec. Their largest limits, located on the North Shore of the St. Lawrence river, in the county of Saguenay, are entirely unsettled except for small lumber towns located along the shore of the St. Lawrence. This land is leased by the pulp and paper companies where wood is cut for pulp. At first, cutting took place along the coast, no company penetrating very far inland, during which time the L.F.P.A. operated towers and patrols along the coast and used telephone lines as their means of communication. As new limits were taken and cutting activities began to extend farther inland, it was found necessary to extend the telephone lines. This was inadequate since the grounded type line is very unsatisfactory over distances of forty or fifty miles. The noise level in the line becomes very high and makes conversation difficult and the maintenance costs, in a country where the only means of transportation is by canoe and portage, becomes excessive. By 1929 the demand for a better means of communication had become so great that the company decided to investigate the possibilities of radio communication.

Radio involved equipment which was much more complicated technically than that used in a telephone system. The equipment involves three units, a receiver for receiving intelligence, a transmitter for sending intelligence and a power supply for these first two units. The capital cost of the equipment itself is much higher. (This is not true today. The capital cost of low power radio equipment is lower than that of a 45 mile telephone line.) But the installation costs are much lower than those of an equivalent telephone line. Maintenance of a radio station is also very low compared with the almost prohibitive maintenance costs previously mentioned with a long telephone line. Hence it was decided to install two stations in 1929, a base station at Manicouagan (see Fig. 1) and a look-out tower and station about seventy miles inland (Tower Taboret). A third station (Tower Bellevue), to be installed in 1930, involved a 125-mile trip by canoe and portage in which there were twenty-three portages.

The requirements first demanded of the equipment were simplicity and good mechanical construction. Operating conditions demanded a transmitting range of 150 miles during daylight on a wavelength of 180 meters. The self-excited oscillator circuit was at this time a popular simple circuit and one that would give a fair degree of frequency stability if properly tuned and handled. Power in this type of circuit is limited only by the power of the tube available for the oscillator. The first transmitters installed were, therefore, ones using the Hartley oscillator circuit with a type 211 tube.

Radio telephony was also desirable since the type of work and traffic was more adaptable to telephone than to telegraphy. Also, using radio telegraphy meant employing telegraph operators which would increase the cost of operating the station. The system of modulation chosen was the Heising or plate system of modulation. This is also a simple circuit, and if the power used is not too high, speech amplifiers are not always necessary.

Hence the complete transmitter consisted of a type 211 tube as oscillator, a pair of type 845 tubes as modulators and a type 210 tube as speech amplifier. The speech amplifier was not used in all stations at first but was later found to increase volume, making about 90 per cent modulation possible. With these tubes, an output of between 75 and 100 watts was obtainable. Complete circuit diagram of the original transmitters is shown in Fig. 2.

The power supply for these transmitters was furnished by a three horse-power gasoline engine, belt connected to a 600 watt, 1,000-12 volt direct current generator, the 1,000 volts being used for the tube plate power supply and the 12 volts for the filament power supply.

The best battery tubes for receivers available at this time were the 5-volt filament type. Consequently, the receivers employed these tubes. The receiver consisted of a stage of tuned radio frequency, a detector, and two stages of audio. This meant the use of storage batteries for filament power supply since the life of dry cells is too short for use on such receivers.

Two such stations were installed in the two towers built in 1929. Communication proved quite satisfactory and in the following year three more stations were installed, one in the tower previously mentioned and two others in another division in another part of the province. These latter two worked independently of the other three. Communication between headquarters and the station located 125 miles inland did not turn out very well. Reception was very weak and quite often traffic had to be relayed by the third station. However, previous experiments with this type of transmitter had shown that the reliable transmitting range was about 100 to 150 miles. This seemed to point to the receivers as the source of trouble.

The type of receiving tube used was not economical. Battery drain was fairly high from the "B" batteries and the filament drain from the storage battery was 1.0 amp. for the receiver. The storage battery had to be charged with the gas-engine generator set used to supply power to the transmitter, and since batteries and gasoline had to be taken into the stations by canoe and portage, a larger and more powerful receiver was not desirable.

The next step was taken when the 2-volt type tubes were introduced. Four such tubes drew 0.24 amp. on the filaments as compared with 1.0 amp. for the old tubes, resulting in a saving on batteries. The "B" battery current was also lower. The triode of the series, the type 30 tube, had an amplification factor of 9.3 as compared with 8.0 with the corresponding type 5-volt tube. The type 32 screen-grid tube, used in the radio frequency stage, had an amplification factor of 610. It also made a more efficient detector. At the same time that these tubes were introduced the air cell battery was also brought into use as a filament supply for the tubes.

This was just what the forestry people wanted. The receivers were remodelled using a type 32 tube in the radio frequency stage and detector stage and a type 30 tube in the two audio stages. The performance of this receiver was much better than the old one and no difficulty was encountered in direct communication with all stations. In addition, costs were reduced by the lower "B" battery consumption, and by the fact that the air cell had taken the place of the storage battery and therefore extra gasoline for the gas engine generator set was not needed. This last was a considerable saving as gasoline costs a minimum of $1.00 per gallon delivered at the stations in the bush.

It now became necessary to install more stations. The same type of transmitter was not chosen, however, as it had been found that the frequency stability of these was not good enough. Sagging or swaying of the antenna in

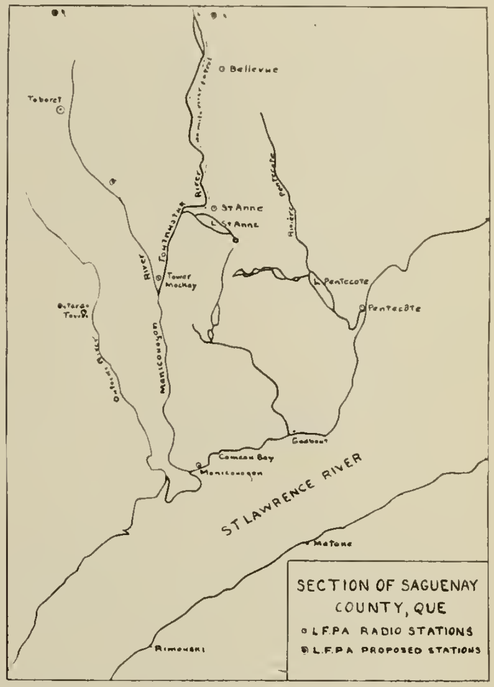


**Fig. 1—Map showing location of towers and the patrol on which the portable was put into service.**

the wind caused slight changes in frequency. Modulation of a self-excited oscillator is also not a good system since frequency modulation is liable to occur unless care is taken. Therefore, the next type of transmitter installed was the oscillator-amplifier type which uses an oscillator tube to generate the radio frequency desired and then a number of radio frequency amplifiers, the number of amplifiers depending on the power desired. The oscillator circuit in this type of transmitter is isolated from the antenna and other outside sources which might affect the frequency and therefore the frequency stability is very good. It is true that this type is more difficult to tune, neutralizing being necessary, but by this time the company had a technical staff of their own and simplicity was not as essential as previously. The two transmitters installed employed a 210 tube as oscillator and a pair of 210 tubes in parallel as amplifier, giving an output of twenty-five to thirty watts. These stations were nearer headquarters and hence the lower power was satisfactory.

The 6.3-volt type heater tubes were now becoming quite popular for battery receiving sets. They are a much more rugged type of tube and of slightly higher power than the 2-volt series. The filaments were designed to operate from storage batteries, which was not desirable as previously explained. However, a new piece of apparatus was on the market, namely, a "Wincharger," which was a wind-driven 6-volt generator with a propeller about six feet in length. This windmill was intended to go with receivers using the 6.3-volt tubes for battery charging purposes and seemed to solve the charging problem as all stations were located on tops of high mountains and a good clean sweep of wind was available.

Higher power receivers were now considered desirable since there was some talk of adopting a system of continuous listening, which meant the use of loudspeakers, and it was decided to install new receivers and Winchargers.

The receiver chosen was a three-tube model, using a type 39/44 tube in a tuned radio frequency stage and the detector stage and a type 38 pentode tube in the audio stage. The receiver was designed to operate on a plate voltage of 90 volts. At this voltage the 39/44 tube has an

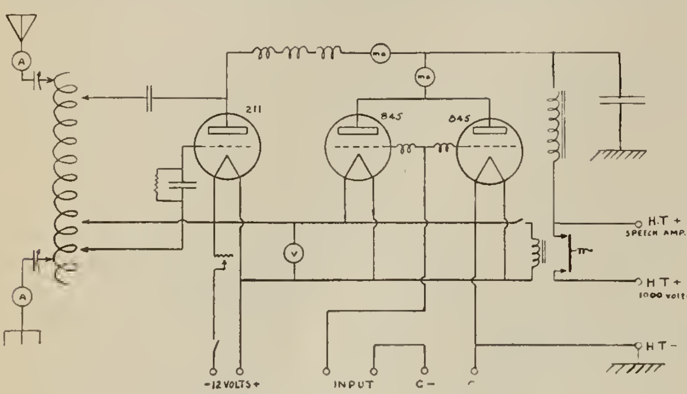


**Fig. 2—Original transmitter installed for forestry communication.**

amplification factor of 960 as compared with 610 for the type 32 tube. The 38 pentode tube has an amplification factor of 120 as compared with 9.3 for the type 30 tube, and it has an output of 0.27 watts which is ample to operate a loudspeaker. With the heater type tubes, resistor bias may be used which dispenses with the use of "C" batteries.

These receivers were installed in all stations during the summer of 1935 along with the Winchargers, and the outfit worked excellently. The Wincharger supplied ample power for charging the batteries and effected an estimated saving of six gallons of gasoline per station per season. Two 45-volt "B" batteries (heavy duty) were found to be good for one season's operation, the total receiver "B" battery drain being only about 16 milliamperes. This was a big improvement in receiver operation, loudspeaker operation being possible with low battery power consumption.

Another type of transmitter was tested in 1935 and installed in 1936. With the introduction of multi-grid tubes, a new method of modulation was also introduced, namely suppressor grid modulation. Modulation is obtained by impressing the modulating voltage on the suppressor grid of the tube. This method is very simple and requires little driving power from the modulator. A pair of type RK-20 tubes were used in an electron-coupled push-pull circuit and a type 210 tube was used as modulator. The electron-coupled circuit gives the advantages of the oscillator-amplifier circuit, but uses the same tube for a double purpose. The cathode, control grid and screen grid are used as a triode in the oscillator part of the circuit while the plate is wired in, in the amplifier part of the circuit. The pair of RK-20 tubes in such a circuit give an output of approximately 45 watts. This type of transmitter is very simple and easy to tune and yet offers the frequency stability of the oscillator-amplifier and a simpler system of modulation. This transmitter worked successfully and was eventually installed at headquarters in place of the original Hartley transmitter.

There was one other problem with which the company were having trouble—that is, dampness. It is not always convenient or possible to keep the stations heated at all times and when this is not done the humidity in the log-cabin-type buildings is very high. Quite often in rainy weather, water would drip from the transmitter racks and panels due to heavy condensation. This was very bad for transformers and other such pieces of apparatus using fine wire for windings, as an electrolytic action is set up which corrodes the wire. Therefore, whenever possible, resistance coupled circuits were used in place of transformer coupled circuits. The speech amplifiers were all remodelled, using the circuit shown in Fig. 4 in place of the original circuit shown in Fig. 3. This did away with transformer T and the chance of breakdown due to humidity was greatly reduced. Also, a great saving was effected in replacements since the price of resistors is about one-tenth that of transformers.

There are now eight stations in operation on the one network. This network is rather large and slightly unwieldy with which to run regular schedules as gas engine generator sets are used for power for the transmitters and these sets must be started and stopped each time a call is made. This takes time and slows up traffic and conversation. Therefore, the next step proposed was to have headquarters listening in at all times and the stations reporting only when there was traffic to send through. Regular listening periods could be established for the stations in the bush so that in-going traffic might be sent when necessary. This system was tried out for several weeks during the summer of 1936 and was found to work quite successfully. However, for a system operated in this manner, the frequency of all stations must be exactly the same and the frequency stability must be very good so that station calls will be heard at headquarters, where the receiver is tuned to the allotted wavelength. Trouble was noticed occasionally during the trials. Slackening of the antenna with the self-excited oscillator units or some

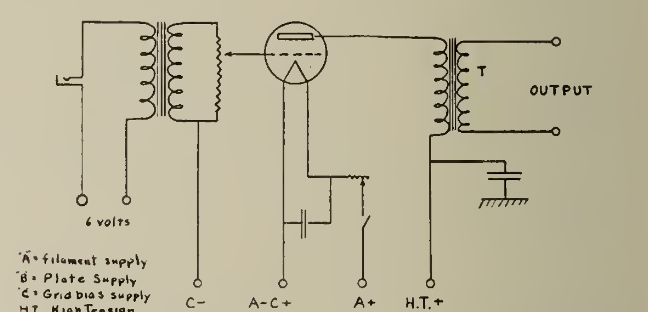


**Fig. 3—Diagram of speech amplifier using transformer coupling.**

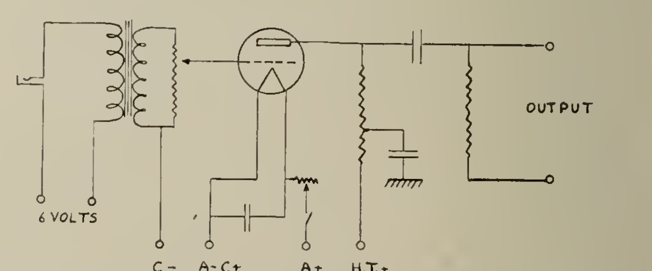


**Fig. 4—Diagram of speech amplifier changed to resistance coupling.**

other similar cause, would cause a shift in frequency and the station would not be heard, or if heard, it would be necessary to retune the receiver in order to bring in the station properly. This is not satisfactory and use of crystal-controlled transmitters is recommended as this type offers about the best frequency stability that can be obtained and assures that a station will always be on the same frequency.

A new branch of the forestry service is just developing, namely, the use of portable radio equipment. The first portable transmitter and receiver was tested during the summer of 1935 and this set consisted of a pair of type 802 tubes in an electron coupled circuit. The transmitter is identical with that previously described using the RK-20 tubes and is shown in Fig. 7, except that the 802 tube is a lower power tube, and gave an output of 2.0 watts on telephony. Microphone and microphone transformer were all that were used for modulation, the output of the transformer being fed directly to the suppressor grids of the tubes. The equipment was highly successful and found to be extremely useful for patrol work and for temporary set-ups where work was being carried on and communication was necessary.

In 1936, a portable set was put into actual service on a hundred-mile patrol. This set did not use the same type of transmitter, but a simple oscillator-modulator set. It was satisfactory provided a technical man was on hand to tune it up, since it had to be retuned each time it was set up and difficulty was encountered in setting the frequency correctly with only the receiver as a means of checking the frequency. However, while in operation it proved invaluable and future plans include a number of portable outfits equipped with emergency battery supplies, good for about eight to ten hours operation, and standard battery supplies, good for a summer's operation. The emergency power supply is to be used in case of fire when it is necessary to travel rapidly and weight must be minimized.

It is unfortunate that complete records of operating data are not available. Before 1934 records were not kept and the only information that is available is that obtained from employees working in the district at the time. During the first two or three years of operation, the percentage of successful calls was quite low. The company did not employ a technical staff but depended upon the manufacturer of their equipment for servicing. In the event of a breakdown, of which there was a considerable number, it took a man at least ten days to get to the stations in the bush, and then not knowing what the trouble was, he might not go prepared. Therefore, though the system of communication was in itself satisfactory, breakdowns in equipment caused long delays in routine communication which greatly lowered the percentage of successful calls. In 1932, the company began to employ a technical staff and from this time on the radio organization began to develop and increase in efficiency. Improvements in equipment and proper and continuous servicing kept the stations in first class condition.

There are some interesting figures available from 1934 to date. In 1934 the percentage successful calls for Bellevue tower was 93.7 per cent while in 1936 it rose to 97.6 per cent. This rise was attributed mostly to the installation of the 6.3-volt type receivers. The total traffic handled rose from 243 messages in 1934 to 601 messages in 1936, and of these, about 65 per cent were routine messages such as weather reports, etc. A new transmitter at St. Anne tower in 1936 increased the efficiency from 86 per cent for 1935 to 98.6 per cent. These figures are for an operating season of about three and a half months.

Some very interesting information was obtained during 1936 when the portable equipment was put into service. A fire broke out about thirty-five miles above Bellevue tower (see Fig. 1). The patrol immediately rushed to the scene of the fire, taking the portable with them. Travelling is not easy in this part of the country and it took two days to reach the scene of the fire from St. Anne tower. The portable was immediately set up and messages sent to Bellevue tower reporting the condition of the fire, the extent and what men and equipment would be necessary to fight it. Under ordinary conditions, it would have taken five days before these men could have investigated the fire and reported back to Bellevue tower with information. The portable stayed at the scene of the fire for eight days and during this time sixteen messages were sent giving details and progress of the fire and ten messages were received with instructions for the fire-fighters. The transmitter operated a total of seven and one-half hours and the receiver a total of ten hours. Not only did this portable equipment save time but it kept headquarters in constant contact with the fire-fighters, thus saving considerable concern and anxiety on the part of many people.

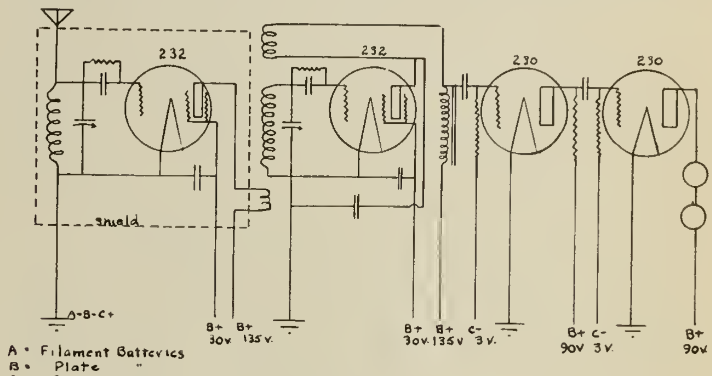


**Fig. 5—Diagram of receiver remodelled for 2-volt tubes. The audio stages were changed to resistance coupling, as shown, at the same time.**

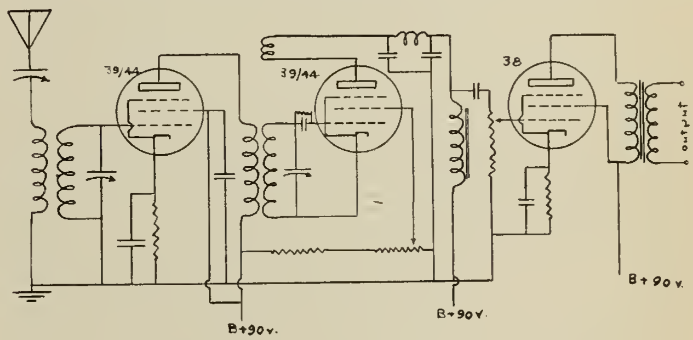


**Fig. 6—Diagram of 6.3-volt type receivers installed in 1935.**

The weight of equipment is an important factor, particularly with respect to the portable equipment. As previously mentioned, all travel in this country is done by canoe and portage, therefore, all equipment and supplies must be transported on the backs of men when travelling on the portages. The average load a man can carry is about one hundred pounds and hence all units sent into the bush must not exceed this weight and they must be of a size which can be carried easily and safely in a canoe. Any equipment weighing over this amount must be partially dismantled and packed in units of proper weight and size, transported, and then reassembled at the station. This has been done in the case of the gasoline engines. Hence light weight, compactness and good mechanical construction are essential. The radio equipment itself is comparatively light, the power supply unit being the one which contributes the major part of the weight. In the portable transmitter previously described, that using 802 tubes, the transmitter-receiver unit weighs only thirty-five pounds whereas the power supply unit (storage batteries and genemotor) weighs fifty-five pounds. Hence there is a total weight of ninety pounds to portage, which is about a full load. This type of equipment is rather heavy for a patrol covering a number of portages but is ideally suited to a river patrol where no portaging is necessary. Experiments have shown that 1.5-watt transmitter, operating under average weather conditions, is reliable for a range of twenty miles and a dry battery power supply weighing about fifty pounds will provide about twenty-five hours operation. For trips of short duration, or where considerable portaging is encountered, lighter weight battery units could be used, weighing about fifteen pounds and supplying about eight hours operation.

Radio has certainly proved itself the best means of communication in this type of country but this does not

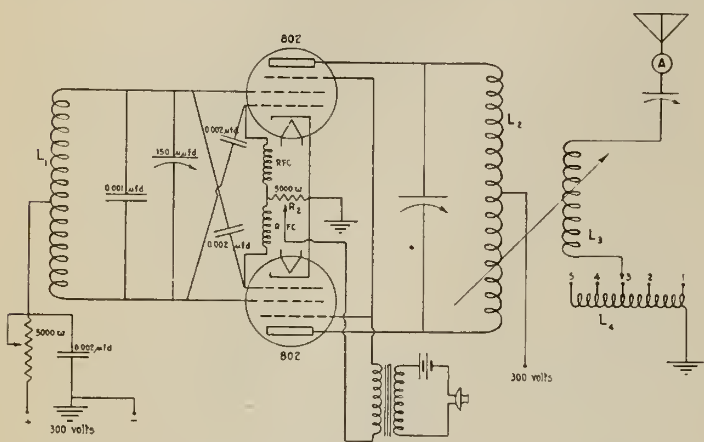


**Fig. 7—Circuit diagram of Marconi portable transmitter, type 48030.**

mean that all telephone lines should be abandoned. The telephone is very satisfactory over short distances or in a well developed country where a two-wire line may be strung on poles along a road. In heavy bush country, the radio is the only solution to the communication problem and it provides a system of communication approaching 100 per cent efficiency whereas a forty-mile telephone line seldom averages better than 75 per cent efficiency. Maintenance costs are very low for radio, the only requirements being gasoline (about three gallons per month per station in the system described) and one set of receiving batteries per season. Another big advantage of the radio system is its flexibility. In the event of fire, portable sets can be taken to the fire and communication provided at the scene of activities. This cannot be done with a telephone line and there is always the possibility of the line being burned and communication completely severed.

There are, of course, disadvantages to the radio system as two-way communication (i.e. conversation as carried on by telephone) is rather costly and has not yet been used for this service and one station must have his say and then close down and listen for the other station. The simplex system has greatly overcome this drawback, as it is only necessary to press a button to speak and release the button to listen for a reply. Another factor entering into the problem is the fact that a technical staff is required to install and supervise these stations whereas the telephone lines can easily be installed and maintained by anyone provided with the necessary instructions.

With the rapid advances in tube design and radio equipment in the past few years, the radio system has proven itself not only practical, but more efficient and easier and less expensive to maintain. It is still a new field and future developments will no doubt bring forth many improvements to provide a still better and more efficient system.

The information contained in the following essay was obtained during the summers of 1934 and 1935 while the author was employed as radio operator at Tower Bellevue and during the summer of 1936 while employed as radio inspector, Division F, for the Laurentian Forest Protective Association.

Figures on operating data were furnished through courtesy of K. G. Chisholm, radio engineer, Laurentian Forest Protective Association.

## APPENDIX I

### History of North Shore Stations

| Station | Date | Transmitter | Receiver |
|---|---|---|---|
| Manicouagan (Headquarters) | 1929 | 211 oscillator, 2–845 modulators, 210 speech amplifier. | 4 tube, 5-volt type. |
| | 1932 | | Receiver remodelled, using 2-volt tubes. |
| | 1934 | | 3 tube, 6-volt type receiver installed. |
| | 1936 | 2–RK-20's, electron coupled circuit, suppressor grid mod. | |
| Tower Taboret | 1929 | 211 oscillator, 2–845 modulators, no speech amplifier. | 4 tube, 5-volt type. |
| | 1932 | | Receiver remodelled, using 2-volt tubes. |
| | 1935 | | 6-volt type receivers installed and Wincharger. |
| | 1936 | 210 speech amplifier added, resistance coupled circuit. | |
| Tower Bellevue | 1930 | 211 oscillator, 2–845 modulators, 210 speech amplifier. | 5-volt type receiver. |
| | 1932 | | Receiver remodelled, using 2-volt tubes. |
| | 1935 | | 6-volt receivers installed and Wincharger. |
| | 1936 | Speech amplifier remodelled to resistance coupled circuit. | |
| Tower St. Anne | 1933 | 2–230 oscillators, telegraphy. | 4 tube 2-volt receiver, all type 230 tubes. |
| | 1934 | 2–210 oscillators, 2–250 modulators. | |
| | 1935 | | 6-volt type receiver and Wincharger installed. |
| | 1936 | 210 oscillator, 210 buffer, 2–801 power amplifiers, 2–59 class "B" modulators, 59 speech amplifier. | |
| Tower Mackay | 1934 | 210 oscillator, 2–210 amplifiers, 2–2A3 modulators. Run from 110 volt A.C. generator and using rectifier unit. | 2.5 volt type, run from generator. |
| | 1935 | | Receiver changed to 6.3 volt type. |
| | 1936 | 2–6L6 modulators. | |
| Pentecote (2nd Headquarters) | 1936 | First Manicouagan transmitter installed here. | 6.3 volt type. |
| Motorship "Lewis L" | 1931 | 2–210 oscillators, 2–250 modulators. This transmitter transferred to St. Anne Tower 1934. | 2 volt type. |
| | 1934 | 210 oscillator, 2–210 amplifiers, 2–2A3 modulators. | 6 volt type receiver. |
| | 1936 | 2–250 modulators. | |
| Outarde Tower | 1936 | Temporary installation. Portable transmitter, 2–802 tubes, electron coupled circuit, suppressor grid modulated. Storage battery and genemotor as power supply. | 6.3 volt type receiver, using a 6D6 tube in detector and R.F. stages and 6F7 tube in audio stage. Wincharger installed. |

# The British Grid System

*Johnstone Wright*

## DISCUSSION[1]

J. B. Challies, M.E.I.C.[2]

The author has furnished a brief and a comprehensive statement of both the historic and the technical highlights of the electrical utility industry of the motherland.

Not only is the paper a valuable contribution to technical knowledge, but it is timely because in this country there has been a good deal of loose talk about the British Grid. For instance, a few of the would-be power savants in the political world on both sides of the International Boundary have been telling an electricity-conscious public, already surfeited with power propaganda of the most misleading character, that some of the growing pains of the electrical industry on this continent would be relieved if something akin to the British Grid were established here. The writer is confident that the author will agree that one of the distinguished leaders of the British delegation to the Third World Power Conference was right when he stated at Ottawa last September that the British Grid was evolving for England precisely what the private power companies of Quebec and the Hydro-Electric Power Commission of Ontario have already secured for the territories they are privileged to serve, namely, a co-ordinated, standardized high-tension network spread over the whole country, fed from the cheapest and most reliable power-producing sources, and having as a primary purpose not only the conservation of natural resources, but a power system that will furnish the best electrical services to all classes of users everywhere at the lowest practicable cost.

A few pertinent facts about the British Grid should be emphasized. It is free from the least semblance of political control; it is not a state-owned enterprise; it was built with private capital subscribed by the general public. It was designed, constructed and is being operated under the supervision of a board of outstandingly successful professional experts who are in no way whatever subject either to governmental direction or political intervention.

It is exceedingly difficult for a Canadian or an American who has not actually studied the electrical generating and distributing facilities of England to understand the great national importance of the Central Electricity Board, of which our guest speaker today is the distinguished Chief Engineer.

Those who were privileged to be in London in 1924 for the First World Power Conference had an opportunity to appreciate the great difficulties which at that time faced the Central Electricity Board. That these difficulties are even now well on the way to a satisfactory solution is evidenced by this paper. Having done so much for the supply phase of the electrical industry, the author is now facing what is perhaps his most difficult task—the standardizing and modernizing of the distribution phase of the industry in England, and concurrently therewith the establishment of uniform rates for electrical services.

Despatches from London during the last few days indicate that the new British Prime Minister, the Right Honourable Neville Chamberlain, is keenly alive to the fine accomplishments of the Central Electricity Board in the generation and transmission fields and that his Government is determined to support the Board in carrying its fine work to its logical conclusion—the distribution field.

From what has already been told us about the British Grid System, we know that in respect of the Central Electricity Board, past performance is but a guarantee of still more notable results in the future. Of these results the author will be able to say with Virgil, "All of these things I saw, and a great part of them I was."

We in Canada, who are concerned with seeing that all classes of the public are furnished electrical services economically and efficiently, will profit from the experiences of the Central Electricity Board and are therefore grateful to the author for his informative paper. We particularly appreciate his coming all the way from London to present it in person.

Dr. R. W. Boyle, M.E.I.C.[3]

Has any trouble been experienced with high voltage cable after it has been placed in service underground? A cable might pass a rigid inspection satisfactorily, also tests at the factory, and then troubles might be experienced in service. Is there any likelihood that nitrogen gas filled cable will displace oil filled type?

E. V. Buchanan[4]

Enquired if existing stations were selected in constructing the Grid system.

The Chairman[5]

Have any tests been made to determine if nitrogen is a more satisfactory gas to use in cables than carbon dioxide?

C. V. Christie, M.E.I.C.[6]

Could the author say something of the problems and troubles inherent to the operation of the Grid system. Have any troubles been caused by surges due to lightning which might cause a shut-down over a large area with a system tied together such as the Grid?

P. T. Davies, M.E.I.C.[7]

What is the best operating efficiency obtained in B.t.u.'s per kw.h.? An efficiency of 10,000 B.t.u. per kw.h. has been obtained in the U.S.A.

Dr. F. A. Gaby, M.E.I.C.[8]

The paper which has been so ably presented is a brief historical outline of the development of the transmission and distribution of electrical energy in England, known as the Grid system, which system is a result of the improvement in the art and the demand for economy in industrial operations along with the desire for improved standards of living.

The writer recalls the visits of Sir Andrew Duncan and Sir Archibald Page to Canada about the year 1924, and discussing with them the principles and economics of the Hydro-Electrical Power Commission undertaking prior to the establishment of this authority and commencement of work on the Grid system in England.

The advent of power in its various forms has revolutionized our industrial operations and changed our social economy. In a large measure it has been responsible for the distribution and re-arrangement of world trade by the rapid advance in its use in industry, transportation and communication, with which our political economy has not

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[1] Paper published in The Engineering Journal, May 1937.

[2] Manager, Water Resources Department, Shawinigan Water and Power Company, Montreal.

[3] Director, Division of Physics and Engineering, National Research Council, Ottawa, Ont.

[4] General Manager, Public Itilities Commission, London, Ont.

[5] Maj.-Gen. A. G. L. McNaughton, C.B., C.M.G., D.S.O., M.Sc., L.L.D., President, National Research Council, Ottawa, Ont.

[6] Professor, Electrical Engineering, McGill University.

[7] Vice-President, Southern Canada Power Company, Montreal.

[8] Vice-President, British American Oil Company, Toronto, Ont.

been able to keep pace in the regulation, adjustment, and co-ordination of the necessary advancements which have resulted in benefits to the industry and improved standard of living.

The present undertaking of the hydro-electric systems of Ontario is the ultimate attainment of such a scheme in which the whole territory to be served is under the control of one administration. The Grid system is the application of such a work to the conditions existing in England, with the fundamental difference in that the source of the supply is from coal in England and water power in Canada. This difference in the source does necessarily require a variance in the rate schedules, but there is a similarity in form. The economy in the application of the principle of high load factors is more evident in Canada with the source of the supply from water power.

One can appreciate the many difficulties that have been encountered in the co-ordination of so many diverse systems, with characteristics so different, and practical problems within a country of old settlements and conservative policies. Although the problem in Canada is different it lends itself more quickly of solution, due to the less density of population and lesser developments at the time of attack, which was twenty years prior to the establishment of the Grid, when transmission and distribution systems had not established themselves to the same extent.

In the United States there is not the same necessity for universal control and units can be established in economic zones within the vast territory to be served. Companies serving areas much larger than those under consideration in England, have made contractual arrangements for interchange of power utilizing both the surplus capacity and energy. Those that are interested will find the Reports of the Super Power Corporation of much interest.

The financial savings are of importance, and form the main considerations in the development of such a work, in addition to the handicaps through lack of economy in manufacture and utilization resulting from the multiplication of equipment and systems with characteristics so different. This same consideration led Ontario to work towards the elimination of duplicate systems, although in view of the very large capital commitments, it was obliged to standardize on two frequencies, twenty-five and sixty cycle.

The lowering of the costs by such economies, by improved load factor, by properly designed rates and through a greater density of customers is of the utmost importance in the extension of the benefits of electrical energy to the community as a whole, including the rural areas.

In Canada, rural use is further encouraged by properly designed Government subsidies.

Would the author state if the voltage is 132,000 between phases and whether radio is used for communication between control centres? Has any interference to telephone communication systems been caused by the operation of transmission lines? In Canada extra precautions are taken to ensure no interference to existing communication systems.

The author is to be congratulated on the comprehensive way in which he has presented the paper covering all features of the Grid development.

The Author[9]

The Central Electricity Board is not a government department and is not subject to political control. Its successful operation depends upon co-operation and understanding between municipalities and companies with the decision of the engineers on the Central Electricity Board. Advisory committees set up in areas are free to make appraisals treating companies and municipalities alike. The Central Electricity Board is not responsible for distribution.

Dr. Boyle's feeling of fear with reference to cable faults can not be appreciated. As an example, a 132,000-volt cable was placed underground for four years without faults aside from small oil trouble. Inspection at the factory was very severe and no real trouble was experienced after the cable was installed. A nitrogen-filled lead-sheathed cable manufactured for the Grid was placed in service for twelve months and when taken out and opened up for inspection was found entirely satisfactory. A cable filled with nitrogen gas is preferable, as carbon dioxide gas is dangerous to men.

The existing efficient stations used in conjunction with the Grid remain in their original ownership but their operation is directed by the Central Electricity Board. Small stations are used to supply peak load only. This should answer Mr. Buchanan.

With reference to Professor C. V. Christie's question regarding the use of lightning arresters, none of these were installed at first but an expenditure of £7,000 per year has been made for the past three years to discover everything possible regarding surge phenomena and this investigation will continue during the next three years. So far, results have proved that a great many lightning arresters which are sold as such do no good at all. The British Grid System has no comprehensive lightning arrester scheme.

The Grid has been designed on the ring system and two feeders are always available. Whenever faults occur they can be cleared as soon as possible. A few interruptions have occurred but they were not serious.

Mr. P. T. Davies' question may best be answered by citing the steam plant at Battersea which is the most efficient, at 12,250 B.t.u.'s per unit sent out, an efficiency of 28 per cent.

In reply to Dr. Gaby, 132,000 volts between phases is correct. The capital required for frequency changes is repaid by levies on the whole supply industry proportionate to the revenue received from the sale of electricity. The Central Electricity Board is financially self-supporting but is not allowed to make any profit. Capital for the conversion of non-standard systems, by their owners, to the 50-cycle frequency basis, adopted as the British standard, is advanced by the board, who are recouped for the interest and sinking fund charges on the money by the levy on industries as already mentioned.

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[9] Chief Engineer, Central Electricity Board, London, Eng.

# Pre-Cast Concrete Units in Engineering Construction

*R. E. Chadwick, M.E.I.C.*

## DISCUSSION[1]

J. F. Brett, A.M.E.I.C.[2]

The author's paper is very stimulating and all those engaged upon the design of engineering structures cannot fail to benefit by a careful study of it.

Pre-cast construction is especially suitable for Canadian conditions by reducing the hazards of pouring in cold weather or in water. A detailed description has been given of many structures such as wharfs, bridge piers and bridges, tunnels, pipes, etc., where the method has been used and his organization has laid some twenty-five miles of pre-cast concrete high pressure water mains from 36 to 72 in. in diameter in the streets of Montreal with complete satisfaction.

Attention of those interested in pre-cast work should be called to a new method of pre-casting realized recently, by the French engineer E. Freyssinet. This method consists of submitting the concrete, as soon as the moulds are closed, to a combination of pressure, heat and vibration. The result is a material which is very different from the usual conception of concrete. Its compressive strength can readily attain 8,000 lb. when taken out of the mould or 14,000 lb. at the age of twelve hours. When the concrete is used as reinforced concrete with pre-stressed steel reinforcing, it is possible to utilize fully the properties of this material.

The method has so far been applied to bridge girders, deep piling, caisson foundations in water, pipes, poles, building frames, floors, etc. It is claimed that it can be applied both to objects moulded in one operation and to works carried out *in situ*. The most important example of the latter is the underpinning of the marine station at Havre.

This new utilization of concrete, which has been called treated concrete, will tend to increase the use of pre-cast members very materially.

E. H. James, M.E.I.C.[3]

The writer agrees with the author as to the superior durability of pre-cast concrete over cast-in-place concrete when subject to the action of salt water and of alternate freezing and thawing. Pier No. 2 at Halifax, built about twenty years ago, was supported on pre-cast concrete piles. When examining this structure a diver looked at the piles, which were found to be in perfect condition below low-water level, although there was a certain amount of deterioration of the concrete between low and high-water levels. Of particular interest was the fact that a number of the piles had been cast too short and had been extended by concrete cast-in-place. In every case the cast-in-place concrete was in worse condition than the pre-cast work.

In the Ballantyne Pier at Vancouver all the concrete exposed to tidal action was pre-cast, with the exception of the small spaces between the pre-cast trusses and the slots in the tops of the caissons into which they fit, and according to Major W. G. Swan[4] this is the only place where any deterioration has taken place in the substructure. The central fill was retained by pre-cast concrete sheet-piles. The only cast-in-place part of the pier was the deck slab.

The author seems to regard concrete cribs with suspicion on account of the small thickness of their walls, which was necessary for flotation. In the two sea-water crib piers at Halifax the only exposed part of the crib wall was entirely below low-water and, therefore, not likely to cause trouble. In both structures there was a waling at low-water level, and a concrete apron-slab, comparatively easy to replace, protected the crib wall in the vulnerable part between low and high-water levels.

A similar method of construction to that mentioned by the author as having been used at Newark Bay was used for the original Second Narrows bridge at Vancouver. There, instead of a pre-cast base resting on piles, however, there was a pre-cast working-chamber built on launchways. After this was sunk, the pier was built inside a cofferdam, which cofferdam was not salved but was left in place.

There seems to be a considerable future for pre-cast concrete in marine work, particularly in cases where it is possible for some time to elapse between the time of casting and the date of placing. This method would be valuable when the pouring could be carried out in the summertime and the placing of the pre-cast units done in the ensuing winter months.

J. P. Leclaire, M.E.I.C.[5]

The author claims to be amazed at the reluctance on the part of many Canadian engineers to adopt the pre-cast method of construction used extensively in Europe for many years. Certain climatical, economical and political conditions, so to speak, prevailing in the eastern part of Canada, and particularly at Montreal, are possibly the cause of such reluctance. The following instance will illustrate this condition:—

When, as chief engineer of the Harbour Commissioners of Montreal, instructions were received to recondition the King Edward Pier, very much dilapidated by age, in order to permit the deepening of its berths to 37 ft. 6 in. below the low water datum (that was, to practically 7 ft. 6 in. below the base of its crib work), it was concluded that the best scheme would be the provision of a series of vertical beams or girders, topped with a reinforced concrete girder, acting as a cope wall in which the mooring bollards were to be incorporated. This cope wall would also act as a distributor of all loads between a group of vertical members, anchored in the rock at their base by means of steel dowels and, near their top, by means of tie rods fastened to reinforced concrete anchor blocks of suitable sizes. It must be remembered that the reconditioning undertaking was to be put in hand at the end of the month of November and completed not later than the 15th of the following April (that is, to be carried out during the winter months while the rising river surface is covered with a sheet of ice over 3 ft. thick) without disturbing the existing sheds and conveyor galleries.

At first, these vertical members were designed as pre-cast structures in the form of a hollow square column, two side walls to act as web members, one as a tension flange, the other as a compression one. These structures over 50 ft. in length, eventually to be filled with a lean concrete, were to be cast horizontally on the lower decks of the sheds and raised to a vertical position for the purpose

[1] Paper published in Engineering Journal, September 1937.
[2] Division Engineer, Montreal Water Board.
[3] Consulting Engineer, Montreal.
[4] Substructure of the Highway Bridge over the Fraser River, New Westminster, B.C., Engineering Journal, October 1937.
[5] Chief Engineer, National Harbours Board, Port of Montreal.

of their placing in their individual locations. Their bulk and weight, however, called for handling by special floating equipment, to be manoeuvred in ice, of size and power which was not immediately available to all tendering parties and whose time of construction would have prohibited the reconditioning of the pier in the time specified. A cast-in-place method was therefore selected for this particular reason.

At the Windmill Point Wharf, where conditions were different from that of the King Edward Pier, a compressed air caisson method was resorted to, also at the Alexandra Pier.

The circumstances described are generally prevalent at Montreal.

The author has mentioned the danger of the reinforcing steel in the pre-cast concrete cribs rusting due to its proximity to the exposed face of the cribs, and it might be pointed out that in Montreal, for that particular reason, the steel bars are so located as not to be closer than 6 in. from the exposed faces, and the concrete is vibrated in order to attain the greatest possible density.

He mentions also the pre-cast concrete blocks used on the Great Lakes over wooden cribs for the narrow band between the high and low water marks. In Montreal, at the time when wooden cribs topped with a mass concrete retaining or quay wall were the standard practice of wharf construction, the cribs were sunk to about 2 ft. below the then lowest recorded water level. On top of the filled cribs, pre-cast reinforced concrete boxes 15 ft. wide, 20 ft. long and 4 ft. high were provided. Concrete was then poured inside these topless and bottomless boxes, and the balance of the wall poured thereon. In order to take advantage of the protection afforded against the deleterious effect of the water on concrete poured in place even with a wooden form, the concrete work was started only when the water was at a convenient level. The fully set concrete of these reinforced concrete forms has proved to resist the action of the water very satisfactorily, while concrete poured behind submerged forms, particularly at the summer levels of the water, was, in many instances, disappointing.

R. F. Legget, A.M.E.I.C.[6]

The author of this interesting paper has presented many statements of a somewhat sweeping nature regarding the use of pre-cast concrete units. This was probably done intentionally, in order to provoke discussion, as his experience is warrant enough for the validity of these statements when applied to unusually large construction work. As the scope of the paper has been widened beyond a consideration of large pre-cast units, it may perhaps be suggested that some of the statements require qualification in respect to the size of job, and of unit, under consideration, and also with respect to local details. For example, it is suggested that "the cost of transporting a given tonnage in the form of completed units from a well located casting yard to the work, is likely to be less than the transportation of the same tonnage of separate ingredients from the point of delivery . . ." This may be true under the "appropriate conditions" mentioned in the paper, but is not the existence of such conditions, considering construction as a whole, more likely to be the exception rather than the rule?

That there are many cases where conditions are appropriate for pre-cast unity will surely be admitted by the most ardent advocate of cast-in-place work. One general type of concrete work not specifically considered in the paper is the building of small isolated structures, such as retaining walls, by means of interlocking pre-cast units of reinforced concrete. European practice in this direction has advanced far in recent years, notably for the miscellaneous structures found along railway lines, where freight handling, from a central casting yard of the railway company, is relatively easy. It would be enlightening to have the author's views on the possible development of this class of work in Canada, obviating as it does transport of plant for small jobs, dubious local workmanship, unskilled inspection, etc.

Although the paper deals essentially with pre-cast concrete units, the author's advocacy of "caisson foundations" raises some intreesting questions in another field of civil engineering. If one such question may be cited, relative to the statements in the first paragraph on page 699, surely the success, or otherwise, of a foundation, and all questions of settlement depend essentially upon a correct appraisal of the nature of the foundation bed material and on its fundamental properties, and the application of this information to design rather than on the adoption of a caisson foundation in preference to any other convenient construction method.

D. W. McLachlan, M.E.I.C.[7]

The author and Mr. James appear to be approaching the problem of justifying the pre-casting of concrete from a wrong direction. The pre-casting of concrete alone is not an insurance against disintegration.

At Sault Ste. Marie there is a 900 ft. lock with 20 ft. lift which is built out of cut stone. When it was built no precautions were taken to prevent the water from the upper level travelling along the back of the south wall and as a consequence 20 ft. of this 900 ft. wall was wet or damp at all times. In winter it is customary to leave the lower gates of the lock open and thus cold air comes in contact with the wet stone surface. In the thirty-five years since the lock was built about ten inches of material has been spalled off a face 900 by 20 ft.

The above is a case where limestone or dolomite of good quality has disintegrated. Many cases in which pre-cast concrete cribs, blocks and piles have disintegrated can be given.

The tops of concrete piles at Halifax, the pre-cast cribs at Carleton Point or Port Borden, P.E.I., and block work around Toronto Harbour are instances. In the above instances pre-casting did not prevent disintegration.

Chemists state that there cannot be any difference between pre-cast and cast-in-place concrete so long as the outside water is kept out of the concrete. Twenty-five years ago when the writer was examining plans for approval at Halifax, the idea of using a protective coating of creosoted lumber around concrete at the water line was considered to be effective and experience has proved nothing else can be done except keep the water content low. According to chemists, 20 per cent of the water used in mixing concrete is required for hydration; the other 80 per cent remains as globules in the mass or in spaces which later refill with water.

The globules when they freeze exert strong explosive forces and cause the disintegration with which all are familiar. Concrete and stone even of good quality will both disintegrate on the exposed sides of spillways of dams if the water content is not kept low. How low the content should be is not known. From experience on the Trent canal lean concrete placed relatively dry has stood the test of time while concrete with at least as great a proportion of cement placed wet has failed to stand against the elements. If the author and Mr. James could show that pre-casting reduced the water content in mixing and placing then they would be making a case for such methods, otherwise, they are not doing so.

[6] Civil Engineer, Faculty of Applied Science, Queen's University, Kingston, Ont.

[7] Engineer, Design and Capital Construction, Department of Transport, Ottawa.

P. B. Motley, M.E.I.C.[8]

A few years ago a railway bridge built in 1912 came to the notice of the writer. This consisted of two plate-girder spans, 120 ft. and 60 ft. long respectively, both resting on a common river-pier. Subsequently a power-development had been installed above the bridge, and the tail-race discharged at some 25 m.p.h. through the opening of the longer span. Not long ago that pier had fallen under suspicion, as it was noticed to have changed in colour to a dirty brown. No certain evidence of disintegration, however, was discovered by a close examination of the surface of the concrete by hammering and picking. Eventually a hole was drilled from the bridge-seat down to the bottom pier, and the core was found to consist to a large extent of material that had a consistency no better than mud. The interesting experiment was tried of introducing air (under 30 lb. pressure) into the hole, when it was found that the water all around the pier bubbled and frothed, leaving no doubt as to the porosity and disintegration of the concrete.

The weathering of concrete structures in the range between low and high-water constitutes a well-known and very serious problem. There was a device adopted in 1871 by the late Mr. H. J. Cambie, an honoured member of this Institute, who covered many piers and caissons—built of the concrete of those days—with 3 in. vertical staves of yellow pine throughout the tidal range. Concrete protected in this simple manner had lasted to the writer's knowledge at least 40 years when in 1912 they were superseded by a new bridge or a bridge in a new location and he continued the use of wood staves. That was twenty-five years ago, and there is no sign to date of deterioration under the staves.

The author is to be congratulated on his exhaustive account of many notable examples of pre-cast concrete work not only in Canada, but in other portions of the world. In his characteristic way, he has clearly, and accurately, recorded many examples of such work, which will be useful to other engineers who may have similar problems.

As a contribution to this discussion it might be suggested that dates be attached to all the examples cited, so as to record the progress of this kind of work. Further, no reference has been made to a very important example of pre-cast work in the field of engineering, and that is, the reinforced concrete pile. The year and place in which the first concrete pile was used is not known, but it was probably in England or France, perhaps under the direction of that famous French engineer, Hennebique.

Most of the structures to which reference has been made are subaqueous, but attention should be drawn to the reinforced concrete pre-cast girders which were used on the Canadian Pacific Railway in Toronto and Montreal between the years 1917 and 1919. These were of T section, 5 ft. deep and 37 ft. long, the top flanges being 6 ft. 6 in. wide, which, when paired with another similar reinforced girder, provided a structure suitable for a single track railway and ballast.

The Toronto structures consisted of two reinforced concrete trestles, the larger of which was 100 ft. high and 400 ft. long, and carried three tracks, while in Montreal the structure in question was the overhead bridge at Atwater Avenue; in each case the pre-cast T beams were 37 ft. long and weighed 58½ tons apiece.

The method of erection of the reinforced concrete girders was the same in all cases. After the substructure, whether it were abutments, piers or towers, had been built at the correct centres the reinforced concrete girders were lowered in by a bridge erection derrick car in the usual manner, working ahead, panel by panel, to completion.

These structures considering their magnitude, span lengths and date, were, as far as known, epoch making.

Their cost was only slightly higher than what steel structures would have cost at that time, steel being at war-time prices, otherwise they might not have been built. They did, however, provide permanent structures with ballasted floors, and have not cost a penny in maintenance, during the 20 years of their existence—which is saying a great deal.

Other members, who have personal knowledge of such structures, would be doing good service if they contributed such details as would complete the reliable record which the author has given in his most interesting paper.

[8] Engineer of Bridges (Retired), Canadian Pacific Railway, Montreal.

The Author[9]

Mr. Brett's brief description of the Freyssinet system of pre-casting, in which a combination of pressure, heat and vibration is used, is exceedingly interesting. Apparently there has been a good deal of research and experimental work along these lines all with the view in general of improving the density and strength of concrete, and with considerable success. All are familiar with the very superior quality of concrete contained in spun concrete pipe where centrifugal force is utilized to remove the excess mixing water and to subject the concrete to pressure while it is setting. It is obvious also that in any centrifugal process there must be certain amount of vibration, on the ground that it would hardly be possible to devise a spinning device that would be perfectly balanced, and perfection in balance would not be a desirable feature even if it could be obtained.

The writer is of the opinion that one will see in the future a great many more pre-cast concrete articles than are available today, and undoubtedly advantage will be taken of the superior facilities afforded in what might be termed factory production to obtain a much stronger concrete than that which we are now producing in the field.

Based on experience as a contractor the writer cannot help feeling that the cost of the various methods of improving the quality of concrete as, for example, by vibrating, is perhaps greater than one thinks it is, and cannot help feeling that there are many cases where the same expenditure in the form of additional cement would produce better results. This is with reference to the average structure in which vibrating is specified. One is inclined to charge to the cost of vibrating certain direct charges comprising the specific items, but is inclined to lose sight of a great many indirect charges and additional overhead expenses that should really be included. In factory production this would not apply to anything like the same extent, as all of the capital cost and installation charges would be applied over the entire useful life of the equipment employed.

Mr. James has brought out some very interesting points of which he is particularly well qualified to speak, such as the reference to the piles in Pier No. 2 in Halifax, and the pre-cast concrete cribs, also in Halifax.

It will be recalled that in Pier No. 2 in Halifax very large pre-cast piles were used, and that these were protected between high and low water with a covering of creosoted timber. As Mr. James mentions, a number of these pre-cast piles which were found to be too short were extended with cast-in-place concrete. It is understood that quite recently Mr. James reported on this pier and, as he mentions in his discussion, he found that in every case the cast-in-place concrete was in a worse condition than the pre-cast work. It is quite interesting to note that below the low water

[9] President, Foundation Company of Canada Limited, Montreal.

mark the piles were found to be in excellent condition after many years of service, and that the surface deterioration was confined to the concrete within the tidal range. This, it is believed, is the usual state of affairs, both in the case of pre-cast and cast-in-place work.

In connection with the cribs in Halifax, he mentions that the only exposed part of the crib was entirely below the low water mark. In this case the argument for thicker walls in these cribs brought out in the writer's paper might very well be modified, as undoubtedly the place where increased thickness and body might be considered advisable, is that band between high and low water level that is exposed to the elements.

Mr. Leclaire mentions the reconstruction of the King Edward Pier as a case where pre-cast concrete had been originally proposed but cast-in-place concrete had to be substituted. Presumably the substitution was made because, owing to the lateness of the season and the fact that the work had to be carried on throughout the winter, it was felt that floating equipment for handling these large pre-cast units might not be available and possibly could not be manoeuvred in the ice. Actually the work was done with floating equipment and was completed within the scheduled time, that is, the opening of navigation in the following spring, but the equipment used might possibly not have had sufficient capacity to handle the pre-cast vertical girders which were apparently originally contemplated and which he referred to as being the better scheme.

The reconstruction of the King Edward Pier was carried out in two sections under two separate contracts, and it so happens that the company with which the writer was associated did both jobs. Tenders for the first contract, consisting of the south side, were called for in the fall of 1928 and the work was completed by the opening of navigation in the following spring. Tenders for the second contract were called in the fall of 1930 and the work was again completed ready for the opening of navigation in the following spring. The scheme consisted of a continuous line of 7 ft. diameter steel caissons sunk to rock in front of the old crib wall, doweled into the rock at their lower ends, filled with concrete placed under water and surmounted with a cast-in-place concrete copewall tied back with heavy anchor rods. The arrangement has proved quite satisfactory but it is agreed that a system of using pre-cast vertical girders might have been better still.

Mr. Leclaire mentions Windmill Point in Montreal which was also a crib wharf that was faced up with more permanent construction. Here the conditions were quite different owing to the fact that it was necessary to carry the new work some considerable distance into the rock to permit of the dredged depth being increased. Obviously it would have been impracticable to have carried open caissons to the required depth and the pneumatic process was used, the new work consisting of a series of rectangular caissons sunk end to end to form a continuous wall. The caissons themselves were of steel, filled with concrete in the usual way. In this particular case a substantial saving in cost could have been effected by using steel for the working chambers only and framing the cofferdam, that is, the portion of the caisson above the working chamber, in timber sheeting with structural steel interior bracing. With this last type of caisson a small saving in cost might be effected by making the timber sheeting removable, but in the writer's opinion any such saving would be quite insignificant compared with the value of the sheeting as a protection against surface deterioration. In this connection it is interesting to note that in New York, where a continuous line of caissons is commonly used in deep foundation work, the practice in regard to the removal of the forms appears to vary, some contractors preferring to remove them, others preferring to leave them in place. This is a clear indication that there is no appreciable saving in cost through the removal of the forms, as caisson work in New York is a highly competitive business in which the contractors bidding are very proficient in their trade. Experience, both as an engineer and as a contractor, leads the writer to believe that the forms should invariably be left in place and form part of the permanent work and be so specified unless there is some particular reason for removing them.

Mr. Leclaire mentions the timber crib wharves in Montreal which are topped with a concrete retaining wall with the timber crib work generally terminating slightly below water level at the time the cribs were built. In certain of these wharves the bottom section of the concrete wall was, as he states, built in the form of large pre-cast reinforced concrete boxes, or hollow blocks, filled inside with cast-in-place concrete, the latter being continued up to the cope level to form the retaining wall proper. Some years ago the writer had occasion to examine these wharves in connection with some proposed repairs and was greatly impressed with the superiority of the pre-cast work in comparison with other similar work in which the concrete at the water level had been cast in place.

There is one remark in Mr. Leclaire's discussion that brings up a rather interesting point in connection with the calling of tenders for public works. He mentions in connection with the King Edward Pier, as one of the reasons for using a system that involved placing the concrete under water, the fact that the bulk and weight of the pre-cast units called for special equipment of a size and power not immediately available to all tendering parties. While this point of view might be dictated by political considerations it is, in the writer's opinion, hardly sound from the economic standpoint. Surely it is not good business or good engineering to forego the use of equipment that might permit of a better type of construction or might result in a lower cost, simply because all contractors who might desire to bid do not happen to have that particular type of plant. This policy carried to its logical conclusion would relegate us to the most primitive conditions and would presumably eliminate the use of any machinery at all. In other words, one would forgo the use of a steam shovel and would mix concrete by hand, on the ground that someone who did not happen to own a shovel or a concrete mixer might desire to submit a tender. Actually the plant that is available to one contractor is usually available to all as, generally speaking, contractors are quite ready to rent equipment to each other or, as an alternative, take a subcontract for any part of a work for which their equipment is particularly well suited. There has been a typical example of this in Montreal during the last two years in the building of concrete cribs in Montreal harbour. The arrangement was presumably advantageous from a financial standpoint to everyone concerned, including the Government.

In reply to Mr. Legget it was the intention to limit the paper to pre-cast units of fairly large size and it is admitted that it is rather difficult to draw a line between what might be considered as comparatively small. In short, the writer would not want to get into a realm of ordinary concrete blocks, pre-cast sills and lintels and pre-cast pipe and similar units of a size that can be ordinarily handled without the aid of machinery.

Remarks in regard to the comparative cost of transporting a given tonnage in the form of completed units and the cost of transporting the same tonnage of separate ingredients refers obviously to a fairly large operation of a type appropriate to the pre-casting method. There are a great many types of work in which the pre-casting system could not be used to advantage, and the statement regarding transportation could not of course apply to these. During the time this paper was being prepared the writers' company was engaged in pouring a concrete deck for a wharf founded in part on caissons and in part on piles. This deck was over the water in a place where one had to contend with a great tidal range. The forms on this particular job were exceedingly costly and the placing of the concrete was also quite costly. This deck could have been pre-cast in a manner that would have given a much better final result at a very substantial saving in cost. The principal saving would have been in the forms and it certainly would have been more convenient to have transported finished units than it would have been to have transported the concrete from a central mixing plant which was located at a site that was convenient to the supply of aggregate rather than convenient to the site of the actual placing.

Mr. Legget's remarks in regard to the smaller pre-cast units and particularly to practice abroad are noted and the writer is inclined to believe that in Europe they are well in advance of us in the use of pre-cast work. There should be a great future for this sort of work in Canada and that in the future one will see a great deal of concrete work cast in central yards located probably close to a satisfactory source of raw material. This would simply be following the change that has already occurred with many other building materials as, for example, cut stone, mill work, etc., which were once completely fabricated at the site of the work but which are now almost invariably completely formed or fabricated in centralized plants often located quite far from the actual work.

As mentioned in the paper, a caisson has been considered as a type of pre-cast work and, as such, a subject that might be properly included in the paper. The writer has been engaged in the caisson business for about twenty-five years and cannot recall from his own practice any instance of a caisson foundation having given any trouble after having been completed. There have been instances of caissons having upset and of caissons which for some reason or other have proved troublesome in sinking, but there are many more instances of cofferdams having given trouble and having completely failed to perform their function of insuring the work being carried out in the dry rather than, for example, of placing concrete under water. It is agreed that there are conditions under which the caisson could not have been used to advantage but in Canada the caisson has not been used to anything like the extent it has been used elsewhere, presupposing of course in both instances that the conditions are appropriate.

Mr. McLachlan appears to take the stand that all masonry, whether it be concrete, stone or a natural rock face, is subject to surface deterioration when exposed to conditions under which it is alternately wet and dry. The writer is in complete agreement on this point but one must recognize that the durability of concrete and of natural stone varies between wide limits. Granite has an exceedingly long life under the conditions referred to. A good grade of limestone also has a very long life, far exceeding that of the mortar in the joints. Certain classes of sandstone have an exceedingly short life. The natural rock at Sault Ste. Marie, which contains numerous horizontal seams, would, as Mr. McLachlan states, erode considerably over a period of years. As regards the relative life of concrete, experience convinces one that the best concrete that can be made today might be expected to have a useful life about equal to that of the poorest grade of stone that would be used as masonry.

Mr. McLachlan states that there is no difference between pre-cast and cast-in-place concrete as long as water is prevented from entering the concrete. This is agreed but it should be pointed out that the structures which have been considered are principally those that are exposed to water and in which it is difficult and perhaps impossible to prevent water from entering the concrete.

All know that in mixing concrete one gets a better result if the water content is kept as low as possible consistent with a workable mix. This, it is believed, is more readily accomplished than in pre-cast work than in cast-in-place work.

Mr. Motley mentions a rather interesting point in connection with concrete deterioration, this being the case of a bridge pier in a tailrace of a power plant which is exposed to a very swift current and in which it was noticed that the concrete had changed in colour to a dirty brown. A closer examination, apparently including the use of hammering and picking, disclosed no certain evidence of disintegration. The change in colour described is in itself conclusive evidence of disintegration in the centre of the pier and, it is understood that this characteristic brown stain is the residue from the passing into solution of certain of the more soluble constituents of the Portland cement, and is a sure sign of disintegration, not so much on the surface as within the body of the structure. This is found in dams and other structures exposed to water under pressure from one side, and it is not surprising to find it in a concrete bridge pier exposed to a very high velocity. It is expected that this concrete would be found to be quite porous.

Mr. Motley mentions the value of pine sheathing as a protection to concrete within the tidal range. He cites the case of certain bridge piers protected in this manner having lasted from 1871 until 1912. The writer happens to be familiar with the piers in question and has always considered them as a most remarkable example of the value of this form of protection. Mr. Motley will agree that when some of these piers were replaced in 1912 and 1913 the reason for their replacement was not that the concrete had lived its natural life but rather that the railway wanted to increase the permissible loading of the bridges.

Mr. Motley mentions a number of bridges on the C.P.R. in which pre-cast girders were used with great success. That at Atwater Avenue in Montreal was, it is believed, at the time it was built the longest span in which this type of construction had been used. The two reinforced concrete trestles with pre-cast decks located just outside Toronto are excellent examples of concrete construction and it is interesting to note that although they are now over twenty years old they have not cost a penny in maintenance.

# Growth and Spread of Arc Welding in Canada

*A. S. Wall, M.E.I.C.*

## DISCUSSION[1]

DAVID BOYD, A.M.E.I.C.[2]

This paper has been interesting and informative and the following are points of particular importance: namely, the details of the various types of joints, the training of operators and the shortage of skilled welding operators at the present time.

Recognized standards are urgently required. Inspectors are frequently appointed by customers and they come with all varieties of specifications. Standards are required to remedy this condition. Finally industries should cooperate and organize a welding school.

GORDON CAPE[3]

The author has dealt with shop technique. Design begins in the office and the co-operation of both office and shop is essential to produce the best product.

The following are a few points which should receive particular attention in the shop:

Make a number of small sub-assemblies and assemble these units. This makes it easier to allow for distortion. Prepare joint edges as accurately as possible; machining is preferable. Avoid clamping members together as clamping is likely to result in cracks. Start at the centre and weld outwards as this makes it easier to control distortion. Make butt welds first. Limit the size of weld, as far as possible, consistent with the strength required. Preheating reduces stresses in the finished assembly.

A. M. MACCUTCHEON[4]

Welding is used in our shops for such work as motor parts.

When welding was first used, about 1920-22, one of our engineers took a small welding set home and proceeded to play with it. It is a most usual occurrence to have the shop report back to the design engineer that a particular design is impracticable and it is impossible to weld it. In our company there is a ready answer. The engineer previously referred to goes down to the shop and completes the welds in question.

W. T. B. MCCORMACK[5]

Welding is used considerably for bridge construction in Australia. A 750 ft. welded bridge over the Snowy river was wrecked by flood waters and many weaknesses were discovered which it was possible to correct in later structures.

In Australia an engineer is always placed in charge of work on welded structures. He is trained in the shop beforehand and is thoroughly familiar with all phases of the work.

MAJ.-GEN. A. G. L. MCNAUGHTON, M.E.I.C.[6]

A 600,000 volt X-ray apparatus is being installed by the National Research Council and it is hoped that use will be made of it for inspecting welded structures.

F. P. SHEARWOOD, M.E.I.C.[7]

This paper has touched on a most important subject, particularly in structural work.

Welding has been a constant education and has shown among other things that structural steel may be distorted very considerably and still stand up. It has shown that the engineer cannot stop at design but must follow the work through welding and assembly. The writer would like to move a hearty vote of thanks to the author for a paper on a subject of such importance.

H. GERRISH SMITH[8]

Welding is extensively used in ship building. Barges are now usually welded and welding is very common for ship forms up to 300 ft.

The largest task to date has been a 15,000 ton oil tanker which is to be entirely welded except for a short distance at each end. The ends are not welded as a convenience in construction.

Practically all yards are welding most of the interior and the outside ends. Each yard conducts its welding school. A considerable amount of mechanical welding is being done. This is more difficult than structural welding on account of the complexity of the assemblies.

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[1] Paper published in the Engineering Journal, September 1937.

[2] Canadian Car and Foundry Company, Limited, Montreal.

[3] Dominion Bridge Company, Montreal.

[4] President, A.I.E.E., and Vice-President, Reliance Electric and Engineering Company, Cleveland, Ohio.

[5] Chairman of the County Roads Board of Victoria, Australia.

[6] President, National Research Council, Ottawa.

[7] Chief Engineer, Dominion Bridge Company, Montreal.

[8] Secretary-Treasurer of the Society of Naval Architects and Marine Engineers and Vice-President, Bethlehem Shipbuilding Corporation, New York.

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# THE ENGINEERING JOURNAL

THE JOURNAL OF
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"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."




VOLUME XX NOVEMBER, 1937 No. 11

## The Joint Meeting with the American Society of Civil Engineers

### Boston, 1937

Three years ago the Annual Convention of the American Society of Civil Engineers took place in Vancouver jointly with the Western Professional Meeting of The Institute. This most enjoyable joint meeting gave our western members an opportunity of greeting one of the Founder Societies of the United States, and led to the formation of many new friendships and the renewal of many old ones.

On October 6th to 8th this year, on a cordial invitation received from the Board of Direction of the American Society of Civil Engineers, an equally successful joint meeting has been held in Boston, Massachusetts, on the occasion of the Society's Fall Meeting. The scenes of the two events are some three thousand miles apart, but this year's assembly, held in the dignified surroundings of the eastern city, was characterized by the same mutual cordiality and goodwill which were so evident in 1934 in the capital of British Columbia. From the beginning, The Institute and its members have received from American engineering societies many evidences of kind consideration, and the American Society of Civil Engineers has been one of the most generous in this respect.

Friendly relations between Canadian and New England engineers are of long standing. Our older members will recall that nearly forty years ago members of the Canadian Society of Civil Engineers journeyed to Boston as the guests of the Boston Society of Civil Engineers, visiting many points of engineering interest and holding joint technical sessions. Boston and its surroundings form an admirable setting for an engineering society's meeting. The historic background of New England, the commerce and industry of Boston and the surrounding district, the educational and cultural features of the cities which face each other across the Charles river, all build up the interest of the gathering. When the traditional hospitality of our American friends is added, the resulting mixture is a very agreeable one.

In accordance with the custom of the Society, its Board of Direction and certain of its committees met on the two days preceding the joint meeting. The officers of The Engineering Institute and their ladies were invited to attend the social functions on these days, which included an excursion to Plymouth for the ladies, and a New England dinner given by the Northeastern Section of the American Society of Civil Engineers in Faneuil Hall, that venerable building which has for so many years been the headquarters of the Ancient and Honourable Artillery Company of Boston.

Local arrangements were in the hands of an executive committee with F. A. Barbour, M.E.I.C., M.Am.Soc.C.E., as general chairman. This body consulted with a co-operating committee appointed by the Council of The Engineering Institute of Canada and consisting of Past-Presidents Fairbairn, Shearwood and Cleveland. The results of the meeting indicate that the Boston executive committee, and the ladies committee—of which Mrs. F. E. Winsor was chairman—are certainly to be congratulated on the manner in which all the events were carried out, and particularly on the smooth working of their arrangements for registration, information and transportation.

After registration at the Statler Hotel on the morning of Wednesday, October 6th, the joint meeting was called to order by Mr. Barbour. He was followed by Professor Albert Haertlein, the President of the Northeastern Section of the Am.Soc.C.E., who expressed the section's welcome to the assembled delegates. The good wishes of the Commonwealth of Massachusetts and of the City of Boston were voiced by the Governor of the Commonwealth and the Mayor of the City respectively.

In the unavoidable absence of President Louis C. Hill, these welcomes were gracefully acknowledged on behalf of the Society by E. P. Lupfer, vice-president, American Society of Civil Engineers, and by President George J. Desbarats on behalf of The Engineering Institute of Canada.

The meeting greatly appreciated the addresses by two outstanding educational authorities, which formed the next item of business. The President of Harvard University, Dr. J. B. Conant, spoke briefly on the policies of the University and the opportunities for engineering and scientific education which are available at the two great institutions in Cambridge. Dr. K. T. Compton, the President of the Massachusetts Institute of Technology, in his address, urged the more extensive application of engineering knowledge to problems of business and public affairs, and pointed out that clear explanations of the economic conditions under which public engineering projects are undertaken are due to the public, but are not always given. He referred to Benjamin Franklin's famous design for a sundial capable of making the time known by firing guns, and quoted the philosopher's conclusion "that many a private and many a public project is like this striking dial—great cost for little profit."

The concluding feature of the morning session was a lecture on The Cultural and Technical Background of the New Architecture by the professor of architecture at Harvard University. Dr. Gropius, who has been a leading figure in the development of new architectural forms in Europe, believes that the present movement towards new methods of expression in architecture affords a favourable opportunity for the rise of a new and distinctively American style.

One of the most interesting characteristics of the meeting was the prominent part assigned to student activities.

The first of these took the form of a luncheon on October 6th, at which some three hundred were present, and which was addressed by Colonel Willard Chevalier, a past director of the Society and one of the principal officers of the McGraw Hill Publishing Company.

The afternoon of Wednesday was devoted to a joint general session conducted by The Engineering Institute of Canada, the chairman being Fred Newell, M.E.I.C. At this session three Canadian papers were presented, dealing respectively with bridge construction, harbour development, and hydro-electric practice. A large audience, including many of our American friends, was greatly interested in this presentation, and the papers gave rise to active discussion which was only limited by the time available.

*Courtesy of the Christian Science Monitor.*

**Prominent Figures of the Opening Session**

Left to right (Standing)—Mayor Frederick W. Mansfield of Boston; James Bryant Conant, President of Harvard University; Edward P. Lupfer, Vice-President, American Society of Civil Engineers; George T. Seabury, National Secretary of the American Society of Civil Engineers. (Seated)—George J. Desbarats, President, Engineering Institute of Canada; Karl T. Compton, President, Massachusetts Institute of Technology; Walter Gropius, Professor of Architecture, Harvard University.

An important feature of Major Swan's paper was his description of the difficulties encountered at New Westminster through the damage, caused by violent freshets in the Fraser river, to two of the piers of the new highway bridge under construction there; the discussion on his paper centred around the methods adopted for dealing with this situation, which proved entirely successful.

The paper by Mr. James sketched the successive stages in the development of the wharf facilities in Halifax harbour. The discussion indicated that a feature of major interest to members present was the information given concerning pre-cast cribs of the permanent concrete type and the data as to recent improved methods of launching them.

Dr. Acres, the author of the third paper, on the Outardes Hydro-electric Project, was unavoidably absent, but was ably represented by A. W. F. McQueen, A.M.E.I.C., whose remarks on the hydraulic and structural features of the scheme were well supplemented by an account of the electrical features of the power installation given by F. M. Hamilton, M.A.I.E.E.

At the entertainment for members and ladies on Wednesday evening, the proceedings commenced with an excellent variety show, followed by buffet refreshments, and terminated with an informal dance, at which the many students present seemed to take the leading part.

Returning to more serious pursuits on Thursday morning, a multitude of important subjects were dealt with at the sittings of the six Technical Divisions of the American Society of Civil Engineers. So many were they, in fact, that a number of members found difficulty in deciding which sessions to attend. The work of the Soil Mechanics and Foundations Division attracted many, dealing as it did with problems in a field of very recent development. Our members from the Maritime provinces were anxious to hear about the latest researches in the study of marine borers. A strong contingent heard the papers and discussions of the Engineering Economics and Finance Division. These were concerned with a subject of primary importance at the present time, namely, the necessity for the better economic planning of public works. The discussion stressed the necessity in the United States for the careful analysis of every proposal to spend money raised by taxation, and for the rejection of every one not economically sound. Incidentally, it may be remarked that this point was not without interest to Canadian members.

At the dinner on Friday evening the chair was occupied by Professor E. T. Moreland, of the Massachusetts Institute of Technology, and the after-dinner speaker was Professor R. E. Rogers of the same institution. His remarks, while apparently somewhat rambling, were greatly appreciated. He touched on many topics of the day, including the retirement of Professor Leacock and the non-retirement of Mr. Aberhart. Passing on to the subject of the engineer and his work, he took as an example the professional activities of James Brindley, as commented upon by Thomas Carlyle, expressing appreciation of the methods of a man who, when planning a great aqueduct or a tunnel for one of his canals, did not require a large staff of assistants armed with slide rules, but retired to his bed and produced his plans by meditation therein. After Professor Rogers' departure, the room was cleared and an excellent orchestra provided music for the dancers.

The closing day of the meeting, Friday, October 8th, was devoted to excursions, which included visits to the engineering laboratories at Harvard, where a demonstration of testing methods was given in the Soil Mechanics Laboratory, and to the Massachusetts Institute of Technology, where the tidal model of the Cape Cod Canal was inspected, and where Professor Edgerton gave a remarkable exhibition of high speed motion pictures. Other parties made longer journeys to Lowell, the Cape Cod Canal and the Quabbin Reservoir. The final event of the day was a "shore dinner" at Swampscott, which gave just the right finish to a most enjoyable and interesting meeting.

*Courtesy of Civil Engineering.*

**Tidal Model of Cape Cod Canal.**

A word must be added as to the arrangements made for the ladies attending the meeting. They included a special visit to the Art Collections at the unrivalled Gardner Museum, at which the Director gave a talk, and a motor drive to Lexington and Concord, with luncheon at the Wayside Inn at South Sudbury. The Canadian ladies particularly appreciated the many kindnesses and the whole-hearted hospitality which they received from the Boston ladies committee.

All The Institute members who took part in the events of the Boston meeting will look back upon it with pleasure, and will look forward to other similar international gatherings as opportunities for further developing the cordial relations between Canadian and American engineers.

## Visit of M. Jacques Rabut, Hon.M.E.I.C.

It will be remembered that an honorary membership in The Institute was awarded at the Semicentennial celebrations to M. Jacques Rabut, an eminent French consulting engineer, who has an international reputation as an authority on reinforced concrete structures. Although unable to be present in June to receive this award in person, M. Rabut has recently paid a visit to the United States and Canada, during which he has delivered a series of lectures at the Ecole Polytechnique, Montreal, on French engineering construction, dealing largely with the works with which his firm has been associated as consultants. M. Rabut is one of the French engineers whose remarkable designs in reinforced concrete seem so daring to engineers accustomed only to North American practice in that material. Among such structures may be mentioned two reinforced concrete arch-rib bridges of 330 ft. span recently completed over the Meuse, and a number of reinforced concrete airplane hangars of 170 ft. span at Cherbourg and Querqueville.

After distinguished service at the front as an engineer officer during the War, he was sent to the United States with the French High Commission, and later served with the French mission in the United States for the purchase

Jacques Rabut, Hon.M.E.I.C.

of equipment for the rehabilitation of the devastated regions in France. He then went to China with an International Commission assembled by the Chinese Government to deal with the reconstruction of the bridge over the Yellow river. On several other occasions he has been retained by the French Government, notably in connection with a large cold storage plant erected in 1919 at Saint Pierre-Miquelon.

While in Montreal, at a luncheon given by a number of members of The Institute Council, M. Rabut took the opportunity of expressing his sincere appreciation of the honour which The Institute had done him in conferring its honorary membership upon him. This he gratefully acknowledged as a compliment to the engineering profession in France. In return Dr. Lefebvre, the chairman, was able to assure M. Rabut that his status is now that of an honoured member of the engineering fraternity in Canada.

## List of Nominees for Officers

The report of the Nominating Committee was presented to and accepted by Council at the meeting held on September 24th, 1937. The following is the list of nominees for officers as prepared by the Nominating Committee and published for the information of all corporate members as provided by Sections 68 and 74 of the By-laws.

List of Nominees for Officers for 1938 as Proposed by the Nominating Committee

| | | |
|---|---|---|
| President: | J. B. Challies, M.E.I.C. | Montreal |
| Vice-Presidents: | | |
| *Zone "B" (Province of Ontario)* | W. P. Wilgar, M.E.I.C. | Kingston |
| | E. V. Buchanan, M.E.I.C. | London |
| *Zone "C" (Province of Quebec)* | H. O. Keay, M.E.I.C. | Three Rivers |
| | Hector Cimon, M.E.I.C. | Quebec |
| *Zone "D" (Maritime Provinces)* | R. L. Dunsmore, A.M.E.I.C. | Dartmouth, N.S. |
| Councillors: | | |
| †*Cape Breton Branch* | A. P. Theuerkauf, M.E.I.C. | Sydney, N.S. |
| †*Moncton Branch* | B. E. Bayne, A.M.E.I.C. | Moncton |
| †*Quebec Branch* | A. Larivière, M.E.I.C. | Quebec |
| ††*Montreal Branch* | J. L. Busfield, M.E.I.C. | Montreal |
| | R. H. Findlay, M.E.I.C. | Montreal |
| | J. W. McCammon, A.M.E.I.C. | Montreal |
| | H. Massue, A.M.E.I.C. | Montreal |
| †*Ottawa Branch* | E. Viens, M.E.I.C. | Ottawa |
| †*Peterborough Branch* | A. B. Gates, A.M.E.I.C. | Peterborough |
| †*Toronto Branch* | Otto Holden, A.M.E.I.C. | Toronto |
| †*Hamilton Branch* | H. A. Lumsden, M.E.I.C. | Hamilton |
| †*Niagara Peninsula Branch* | W. R. Manock, A.M.E.I.C. | Fort Erie, Ont. |
| †*Sault Ste. Marie Branch* | J. L. Lang, M.E.I.C. | Sault Ste. Marie |
| †*Lethbridge Branch* | J. T. Watson, A.M.E.I.C. | Lethbridge |
| †*Winnipeg Branch* | A. J. Taunton, M.E.I.C. | Winnipeg |
| †*Calgary Branch* | J. Haddin, M.E.I.C. | Calgary |
| | G. P. F. Boese, A.M.E.I.C. | Calgary |
| †*Victoria Branch* | I. C. Barltrop, A.M.E.I.C. | Victoria |

*One Vice-President to be elected for two years.
†One Councillor to be elected for two years.
††Two Councillors to be elected for three years each.

*Additional Nominations*

Section 68 provides also that "Additional nominations for the list of nominees for officers signed by ten or more corporate members and accompanied by written acceptances of those nominated, if received by the Secretary on or before the first day of December, shall be accepted by the Council and shall be placed on the officers' ballot."

## Discontinuance of the Non-Active List

It will be remembered that a non-active list was established by Council in 1932 to meet the case of those members who in consequence of the depression were unable to pay their annual fees to The Institute. At one time the list included over seven hundred names. To-day the number remaining is so small that Council has felt justified in discontinuing the list as of January 1st, 1938, on which date the names of the non-active members will be restored to the regular roll.

It is possible that this will affect a few members for whom the situation has not materially improved. In such cases Council would appreciate a confidential communication to the Secretary explaining the member's difficulties, so that on application, such cases may receive further consideration by Council.

# OBITUARIES

## William Gregory Chace, M.E.I.C.

William G. Chace, M.E.I.C., consulting engineer, died suddenly on July 12th, 1937, at his home in Toronto at the age of sixty-two, his death closing an active career in engineering extending over a period of thirty-five years.

He was born on May 16th, 1875, in the county of Lincoln, Ontario, and was educated at St. Catharines Collegiate Institute and the School of Practical Science, Toronto, graduating from the latter with honours in 1903.

William Gregory Chace, M.E.I.C.

After a short time teaching he joined the staff of the Canadian Niagara Power Company, which was then busy with the construction of the first hydro-electric power plant to be built on the Canadian side of the river at Niagara Falls. In 1904 Mr. Chace was appointed engineer-in-charge of construction on the hydro-electric power plant of the International Railway Company at Niagara Falls and in 1905 and 1906 was engaged on preliminary studies for the electrification of Temiskaming and Northern Ontario Railway and on reports for the first Hydro-Electric Power Commission of Ontario.

In 1907 he became a member of the firm of Smith, Kerry & Chace, consulting engineers, Toronto, and took charge of the preparation of a report to the city of Toronto which resulted in the establishment of the Toronto Hydro-Electric System. From 1908 to 1911 Mr. Chace was chief engineer on the construction of the Municipal Hydro-Electric Power System of Winnipeg with generating plant at Pointe-du-Bois. In 1912 he was appointed assistant general manager of the Mount Hood Railway, Light and Power Company, Portland, Oregon, and in 1913 as president and chief engineer of the Crane Falls Power and Irrigation Company, Boise, Idaho, constructed an irrigation system serving 30,000 acres of land.

Late in 1913 Mr. Chace was appointed chief engineer for the Shoal Lake Aqueduct of the Greater Winnipeg Water District where he remained until the completion of that undertaking in 1920. From 1920 to 1924 he occupied the position of President of the Canada Lock Joint Pipe, Limited. Later, his time up to 1928 was devoted mainly to the study of the properties and utilization of reinforced concrete pipe.

In 1928 Mr. Chace became a member of the firm of Sullivan, Kipp and Chace, consulting engineers, Winnipeg, and prepared special reports for the Government of Saskatchewan dealing with the general electric power supply system in that Province and later taking charge of the construction of two extensive plants for central steam heating in the city of Winnipeg, for the Northern Public Service Corporation.

Mr. Chace returned to Toronto in 1932 and working in conjunction with his old firm Kerry & Chace, Limited, made, in 1933, reports on the supply of hydro-electric power to the gold mines in Northern Quebec. In 1934 he prepared preliminary designs for a hydro-electric power development on the Upper Ottawa river for Noranda Mines Limited and in 1935 designed and built a hydro-electric power plant for God's Lake Gold Mines, Manitoba. In 1936 Mr. Chace had charge of the construction of a 48-inch supply pipe and storage dams for the Quesnel Mining Company, Limited, British Columbia.

Mr. Chace joined The Institute as an Associate Member in 1906, became a Member in 1912, served as chairman of the Winnipeg Branch in 1915 and 1916, as a councillor of The Institute from 1915 to 1917 and as a Vice-President in 1920 and 1921. He was awarded the Gzowski Medal in 1911.

## Clyde Barber Joy, A.M.E.I.C.

It is with deep regret that we record the death of Clyde Barber Joy, A.M.E.I.C., in Hamilton, Ont., on April 27th, 1937, after an illness of eight months. Mr. Joy was born in Hamilton, North Dakota, in March 1896 and moved to Toronto when a boy. In 1917 he joined the Canadian Flying Corps and after the war entered Toronto University graduating in 1924 with the degree of B.A.Sc. in Civil Engineering. In 1924 he was employed as draftsman by the Canadian National Electric Lines, Toronto, and in 1925 by the American Bridge Company, Pencoyd, Penn. In the latter part of 1925 he joined the Austin Company in their estimating and architectural department in Philadelphia. He returned to Canada in 1930 as designer and estimator with the London Structural Steel Company, London, Ont., later being employed by James, Proctor & Redfern, Limited, Toronto. Mr. Joy joined The Institute as a Student in 1920, transferring to the grade of Junior in 1925 and became an Associate Member in 1931.

## Claude Wilson Morrison, S.E.I.C.

It is with regret that we record the passing of Flight-Lieut. Claude Wilson Morrison, S.E.I.C., who died in Belleville, September 15th, as a result of injuries received in a motor accident. Flight-Lieut. Morrison was born in Montreal in May 1908, receiving his technical education at McGill University from which he graduated with the degree of B.Sc. in Mechanical Engineering in 1931. He joined the Royal Canadian Air Force in 1932 and had been stationed at Camp Borden, Trenton and Ottawa. At the time of his death he was at the air station at Trenton, Ontario.

## Harold Rolf, M.E.I.C.

In the passing of Harold Rolf, M.E.I.C., at his home in Lachine, Quebec, on September 19th, Canada lost one of her outstanding engineers. Mr. Rolf at the time of his death was President of the J. S. Metcalf Company, having joined the firm in 1904 as inspecting engineer and reached the position of President by 1917. His company was well known as designers and builders of grain elevators in United States, Great Britain, South America and all parts of Canada. Mr. Rolf was born in Toronto, Ont., February 1872 and graduated from the School of Practical Science, Toronto, in 1894. From 1895 to 1897 he was engaged in drafting and design with the Pacific Rolling Mills, San Francisco, and from 1897 to 1902 in mining and surveying in British Columbia and the Yukon Territories. He joined The Engineering Institute of Canada as an Associate Member in 1909, becoming a Member in 1920.

### Harry George Rogers, A.M.E.I.C.

The death of Harry George Rogers, A.M.E.I.C., in Toronto in June 1937 will be noted with regret. Mr. Rogers was born in Peterborough in November 1884 and received his education at Trinity College School, Port Hope, Ont., and McGill University. He acted as field inspector for the Canadian Inspection Company from 1908 to 1910 and bridge inspector for the Canadian Pacific Railway from 1910 to 1914 and again from 1928 to 1931. From 1925 to 1928 he was on the construction and design for the Toronto Terminals Railway station. In 1932 Mr. Rogers moved to Toronto where he resided at 118 Howard Park Avenue.

### Andrew Douglas Stalker, A.M.E.I.C.

We regret to announce the death in Ottawa on September 30th, 1937, of Andrew Douglas Stalker, A.M.E.I.C. While Mr. Stalker only recently joined The Institute as an Associate Member, he has been engaged in engineering for the past twenty-five years. He was born in Ottawa in November 1892, receiving his education at the Ottawa Public Schools and Queens University from which he graduated in 1916. From 1916 to 1919 he served in Canada and overseas as works officer of the 38th Battalion, C.E.F. From 1919 to the time of his death he was in the employ of the waterworks department of the city of Ottawa, first of all in the construction of the overland pipe extension and distribution system Eastview, and the low lift pumping station, Lemieux Island. From 1929 to 1930 he acted as resident engineer on the construction of the Ottawa water purification plant and pumping station extension. In 1933 he became assistant waterworks engineer, which position he held until the time of his death.

## PERSONALS

R. G. Barbour, S.E.I.C., has been appointed industrial engineer with T. Pringle and Son, Limited, Montreal. He is a graduate of the University of New Brunswick, receiving his degree in B.Sc. in 1924 and M.Sc. in 1927. From 1926 to 1929 he was electrical engineer on construction with the Aluminum Company of Canada at Arvida, Quebec, and since 1929 has been electrical engineer with Messrs. McDougall and Friedman, consulting engineers, Montreal.

K. Y. Lockhead, Jr.E.I.C., has recently been appointed building superintendent of the Hudson's Bay Company's retail store at Winnipeg. Mr. Lockhead graduated from McGill University in 1932, acted as demonstrator in the mechanical engineering laboratory of the same university until 1933 when he joined the Hudson's Bay Company at Winnipeg as assistant to the power plant engineer.

H. G. Conn, A.M.E.I.C., has joined the Mechanical Engineering Staff of Queens University. Mr. Conn graduated from Queens University with the degree of B.Sc. in Mechanical Engineering in 1931, receiving an appointment as demonstrator in the Physics Department of the same university. In 1932 he joined the staff of the Proctor and Gamble Company, Hamilton, Ont., and since 1935 has been plant engineer at their Hamilton plant.

E. J. Davies, A.M.E.I.C., has been transferred from the Peterborough Collegiate and Vocational School, where he has been acting as instructor, and has been appointed director of industrial arts in the new Vocational School at Cornwall, Ont., which will open in September 1935. He graduated from the Nova Scotia Technical College in 1923 with the degree of B.Sc. in Mining Engineering. From 1924 to 1929 Mr. Davies was with the Babcock-Wilcox and Goldie-McCulloch, Ltd. Galt, Ont., and in the latter year received the appointment which he now vacates.

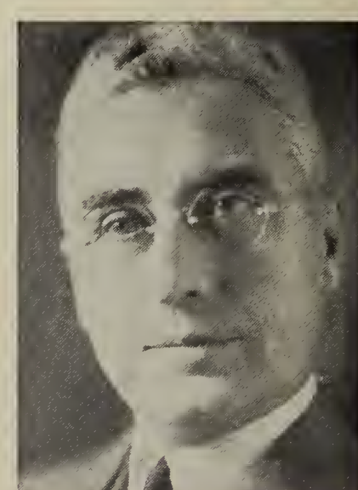
J. T. Williams, S.E.I.C., has accepted a position with the Imperial Oil Company at Sarnia, Ont. Mr. Williams graduated in mechanical engineering from Queens University in May 1937.

W. A. Dawson, A.M.E.I.C., has resigned from the staff of the Algoma Steel Corporation, Sault Ste. Marie, Ont., to accept the position of mechanical superintendent of the new motor plant of the Chrysler Corporation of Canada, Windsor, Ont. He graduated in mechanical engineering from Queens University in 1923 but prior to graduation had considerable experience as a tool and die maker and inspector of tools and gauges. Mr. Dawson was associated with the Ford Motor Company of Canada, Windsor, Ont., for a number of years and advanced to the position of chief of the department of machine and tool design. In 1935 he received the appointment from which he has just resigned, that of assistant superientendent of the Algoma Steel Corporation.

P. L. O'Shaughnessy, A.M.E.I.C., has accepted a position as field engineer with Messrs. Robinson and Steinman, consulting engineers, on the Thousand Islands Bridge. Since 1934 he has been construction engineer with the Canada Cement Company and prior to that was highway engineer to the Ontario Government. From 1928 to 1933 he was plant engineer with the Canada Cement Company, Belleville, Ont. He graduated from McGill University in 1923 and later became a qualified Dominion Land Surveyor in New Brunswick.

C. D. Meals, M.E.I.C., has been appointed chief engineer of the Wire Rope Division, Bethlehem Steel Corporation, Williamstown, Penn., thus terminating his connection with B. Greening Wire Company Ltd., Hamilton, Ont., where he has been since 1931. Mr. Meals has had extensive experience in the wire rope and cable industries and will be remembered for his numerous technical papers on these subjects. His connection with this industry started in 1911 when he became draftsman with the John Roebling's Sons Company, Trenton, N.J. This appointment was followed by others with the Bethlehem Steel Corporation and the American Cable Company, with whom he was chief engineer from 1927 to 1930. From 1930 to 1931 Mr. Meals was president and general manager of the Wire Rope Corporation of America, New Haven, Conn.

#### Shawinigan Appoints Assistant General Managers



J. B. Challies, M.E.I.C.

The following promotions to the executive staff of The Shawinigan Water and Power Company were announced recently by the president of the company, Dr. Julian C. Smith, past president of The Institute: Messrs. J. B. Challies, P. S. Gregory and John Morse, all Members of the Institute, also Mr. R. J. Beaumont, to be assistant general managers.

Mr. Challies began his professional career in 1903 as engineering clerk in Topographical Surveys of Canada. Successively, chief hydraulic engineer, Department of Interior; superintendent of Water Power; director and chief engineer, Water Power and Reclamation Service; director, Dominion Hydrometric Survey; member, Dominion Power Board; member, Dominion Fuel Board; consulting engineer to Department of External Affairs regarding International Waterway matters; liaison officer for the Federal Departments on the Research Council of Canada. He represented the Government of Canada in 1915 at the International Engineering Congress in San Francisco, and in 1924 at the World Water Power Conference in London. Resigning from the Federal Government Service in 1924 he became a departmental manager of Shawinigan, Montreal.

P. S. Gregory, M.E.I.C.

John Morse, M.E.I.C.

Mr. Gregory began his professional career in Hamilton with the Canadian Westinghouse Company; he was then with the Montreal Tramways Company and the Electrical Commission of Montreal. After two years on construction of the street-lighting system for the City of Montreal, he, in 1918, joined Shawinigan. In addition to his duties as assistant general manager, Mr. Gregory is assistant to the president of the Quebec Power Company.

Mr. Morse graduated in electrical engineering from Chalmers Technical Institute, Gothenburg, Sweden, in 1906, and started his professional career as a draughtsman with the Otis-Fensom Elevator Company, Yonkers, N.Y. There followed some time with the Maxwell Briscoe Motor Company, Tarrytown, N.Y., and the General Electric Company at Schenectady, N.Y. In 1907 he joined Shawinigan and four years afterwards became superintendent of operation. In 1916 he was made general superintendent, a position he has held until his recent appointment as assistant general manager.

## 17th World Congress of Industrial Chemistry

At the request of the Seventeenth Congress of Industrial Chemistry, Major D. C. Unwin Simson, R.C.E., A.M.E.I.C., was appointed by the Council to represent The Institute at the meetings of the Congress which were held in Paris, France, from September 26th to October 3rd, 1937. Major Simson is resident engineer of the Canadian Battlefields Memorial Commission, St. Laurent Blangy (P. de C.), France, and submits the following report of the proceedings of the Congress:

On Sunday the 26th the delegates were received by the President, Sir Robert Mond, and M. M. G. Painvin, President of the Committee of Organization, M. Gerard, Vice-President of the Society of Industrial Chemistry, and other notabilities, in their magnificent building, 28 bis Rue St-Dominique, on the left bank of the Seine.

After the presentations, all the delegates repaired to the main hall, where dancing and attractions alternated for the entertainment of the visitors, coupled with an excellent buffet.

On Monday morning, after being photographed in the court-yard of the Maison de Chimie Industrielle, at ten o'clock about 200 delegates assembled in the hall of the building and the Congress was declared open by M. Max Hymans, Under-Secretary of State for Commerce and Industry.

This was followed by a conference conducted by Sir Robert Mond, member of The Institute of France and President of the Society of Industrial Chemistry, on the "Growth of the Nickel Industry." This brought Canada very much before all the delegates as practically the whole of his speech dealt with the growth of the Canadian nickel industry, only passing mention being made of that of New Caledonia and Finland.

This was followed by a reunion of the presidents, vice-presidents and secretaries of the various sections of which there were 17. These were as follows: Section 1—Analytical chemistry; 2—(*a*) Factory lay out and installation, (*b*) Water treatment; 3—Combustible solids; 4—Combustible liquids; 5—Minerals; 6—Electro-chemistry; 7—Lime, cements, etc.; 8—Glass; 9—Industrial organic products; 10—Fats; 11—Resin and rubber, etc.; 12—Cellulose, paper, artificial textiles; 13—Tannery; 14—Fermentation, beers, sugar; 15—Primary foods, bakery, fruit preserving, etc.; 16—Technical agricultural chemistry; 17—Scientific organization.

From this moment until Thursday, September 30th, these sections of the Congress were in almost continual session from 9 a.m. until 5 p.m. with a break for lunch.

On the afternoon of the 27th was opened, in another part of the building, an exhibition of the latest laboratory equipment. Exhibits from French and German firms predominated and the machinery varied from scales designed to weigh infinitesimal particles to crushers for analytical purposes. This was followed at 6 p.m. by a full conference of the Congress on "The Importance and Development of Artificial Fibre in Germany." This paper was given by Dr. W. Eller, head of the Central Office of the Artificial Silk Industry.

On September 28th, a full conference was given on "The Action of Silicates on Modern Life," by S. A. Artigas, director of High Studies at the Polytechnique of Madrid. At 5 p.m. the delegates were received at the Chamber of Commerce of Paris, where the band of the Republican Guard were in attendance.

On the 29th, conferences were held by W. S. Muller, professor of the Technical School of Vienna, on the "Corrosion of Metals in Solution Considered as an Electro Chemical Phenomenon," by L. M. Heilbrown D.S.O., D.S.C., Ph.D., F.R.S., director of the chemical laboratories of Manchester University, on "Ten Years of Research on Vitamin 'D'"; and a further conference at the Sorbonne, in the amphitheatre, on "Liquid Air," by Georges Claude.

The following day all sections wound up their business, and in the afternoon the President of the French Republic, M. Lebrun, arrived and was greeted by Sir Robert Mond as President of the Society. After the presidential party had taken their seats, the business of the closing of the Congress commenced under the leadership of M. Jean Perrin, Nobel Prize winner, member of the Institute of France and late Under-Secretary of State for Scientific Research. Speeches were made commemorating the foundation of the Society of Industrial Chemistry, under the Presidency of M. Jules Jullien, Under-Secretary of State for Technical Science. Later a visit was made to the Exposition of International Art and Science, at the pavilion of the Corporative Union of French Art, followed by an official banquet presided over by M. Paul Ramadier, Under-Secretary of State for Public Works, at the restaurant Roi Georges V.

This concluded the theoretical and business side of the Congress which now split into four different groups for a three day trip to visit different objects of interest. This started on Friday, October 1st, and Group 1 visited the Goodrich factory, at Colombes; 2—The Laboratories of Dr. Roussel, at Romainville; 3—The factory of "Pain Vibor," at Paris; 4—The studios of Pathé Cinéma, at Joinville.

On Saturday, Group 1 visited the new Chemical Laboratories of the Ecole Normale Supérieure and the new Laboratories of the City of Paris.

The other groups left on a visit to Alsace to inspect the potash mines and chemical products of Thann and Mulhouse, also the power installation on the Rhine, at Kembs. On Sunday, after an excursion through the picturesque country of the Vosges around Mulhouse and Colmar, the delegates returned to Mulhouse where they took train for Paris, after a most successful and interesting Congress.

Great credit is due to the organizers for the efficient method in which the delegates were looked after and the business of the Congress carried through.

## The Engineering Journal 1930-1936

An interesting classification of the technical papers published in the Engineering Journal during the years 1930 to 1936 inclusive has been made recently and a summary of this is given here for the information of the members.

The first line of the table gives the number of technical papers included in each classification, the total amounting to three hundred and twelve. The second line gives the approximate percentage which each group is of the total.

| Mechanical and Aviation | Civil and Structural | Electrical including Radio | Mining, Metallurgical and Chemical | Various |
|---|---|---|---|---|
| 80 | 85 | 64 | 29 | 54 |
| 25% | 27% | 21% | 9% | 18% |

## ELECTIONS AND TRANSFERS

At the adjourned meeting of Council held on October 25th, 1937, the following elections and transfers were effected:

*Member*

BEAVER, Hugh Eyre Campbell, consltg. engr., partner in firm of Sir Alexander Gibb and Partners, Queen Anne's Lodge, Westminster, England.

*Associate Members*

MUNRO, George Neil, B.Sc. (Univ. of Sask.), inspr., Dept. Public Works Canada, North Battleford, Sask.

PATRIARCHE, Valance Heath, B.Sc. (Univ. of Man.), general traffic manager, Canadian Airways Limited, Winnipeg, Man.

SEELY, Harold Chipman, B.Sc., (Univ. of N.B.), 1197 Crawford Bridge Road, Verdun, Que.

THEOBALDS, Thomas Reynold, B.Sc., (McGill Univ.), town engineer to the Castries Town Board, St. Lucia, B.W.I.

*Juniors*

McLAUGHLIN, William Gordon, B.Sc. (Queen's Univ.), M.E. (Mech.), (Rensselaer Polytechnic Inst.), asst. constrn. engr., E. B. Eddy Co. Ltd., Hull, Que.

RAMSAY, William Wallace, B.Sc. (Univ. of Man.), res. engr., Century Mining Corpn. Ltd., Elbow Lake, Man.

WALSTON, Timothy Cragg, B.Sc. (Univ. of Man.), archt'l. dftsman., Green, Blankstein, Russell & Ham, Winnipeg, Man.

*Transferred from the class of Junior to that of Associate Member*

GILCHRIST, John, B.Sc. (Univ. of Man.), district plant engr., The Barrett Company, Montreal, Que.

THOMPSON, Frank Lawrence, B.Sc. (N.S. Tech. Coll.), technical service engr., Imperial Oil Limited, Dartmouth, N.S.

*Transferred from the class of Student to that of Associate Member*

HAWKE, Charles Edison, B.A.Sc. (Univ. of Toronto), asst. engr., Dept. Public Works Canada, Toronto, Ont.

*Transferred from the class of Student to that of Junior*

MACREDIE, John Robert Calderwood, B.Sc. (Univ. of N.B.), instr'man., Dept. of Highways of N.B., Fredericton, N.B.

*Students Admitted*

ASPLIN, Albert Grant, (McGill Univ.), 3592 University St., Montreal, Que.

BAKER, Rogerson Albert, B.A.Sc. (Univ. of Toronto), 264 Hunter St., Peterborough, Ont.

FERGUSON, David H., (McGill Univ.), 3637 Oxenden Ave., Montreal, Que.

FERGUSON, Robert Norman, (McGill Univ.), 3637 Oxenden Ave., Montreal, Que.

JOYCE, William Anderson, (R.M.C.), Royal Military College, Kingston, Ont.

MENDELSOHN, Albert, (McGill Univ.), Ste Agathe des Monts, Que.

MULLINS, Harrison Alexander, B.Sc. (Univ. of Man.), 524 Dominion St., Winnipeg, Man.

McLEOD, Arthur Malcolm, B.Sc. (Univ. of Alta.), 18 Harvey St., Hamilton, Ont.

OATWAY, Harold Calahan, (McGill Univ.), 2059 Stanley St., Montreal, Que.

POLSON, Jack Ambrose, B.A.Sc. (Univ. of B.C.), 194 Reid St., Peterborough, Ont.

RUBIN, Leon Julius, (Univ. of Toronto), 539 Palmerston Blvd., Toronto, Ont.

SNYDER, William Garrett, (McGill Univ.), 2063 Stanley St., Montreal, Que.

WHITELEY, Eric, B.A.Sc. (Univ. of Toronto), 301 Reid St., Peterborough, Ont.

**ANNUAL GENERAL**

**and**

**GENERAL PROFESSIONAL MEETING**

**Hotel London**

**London, Ontario**

**January 31st, February 1st and 2nd**

**1938**

# Committee on Foundations in Winnipeg, Manitoba

**Interim Report as presented to the Executive Committee of the Winnipeg Branch of The Institute, August 5th, 1937**

During the summer a committee of engineers and other technical men investigated the problem of soil conditions in the Winnipeg district with particular reference to foundations. As there seems to be a widespread interest in the subject of foundation engineering and soil mechanics at the present time, it is believed that the publication of their report will be of interest.

After amending Recommendation 3, as shown at the end of the report, this report was adopted by the Technical Bureau of the Winnipeg Board of Trade. It was then submitted to the Council of the Board on September 27th, adopted and released to the City Council, Winnipeg Builders Exchange, Winnipeg Real Estate Board, Home and Property Owners Association, Provincial Department of Public Works (Architects Branch), Mortgage Loans Association, the Press and other interested parties.

A further report may possibly be forthcoming but this will depend largely whether sufficient funds are raised to carry on investigation work.

To The Executive Committee,
Winnipeg Branch, E.I.C.,
Winnipeg, Manitoba.

Gentlemen:

At your executive meeting of April 23 last, the following resolution was moved, seconded, and carried: "That Professor A. E. Macdonald as chairman, assisted by Professor W. F. Riddell, form a co-ordinating committee on the study of foundation conditions in Winnipeg and that they contact other interested bodies in this respect."

Following these instructions an organization meeting was held on May 10. This was attended by representatives of The Engineering Institute of Canada, Winnipeg Branch; the Association of Professional Engineers of the Province of Manitoba; the Manitoba Association of Architects, and the Manitoba Branch of the Canadian Institute of Chemistry. Further meetings were held on June 24, July 8, and July 29, 1937.

Your instructions to this committee were to report on this subject under the following three headings:—

1. Why difficulties are experienced with foundations.
2. How best to repair faulty construction.
3. Proper design for new foundations.

The correct answers to these three questions are matters of considerable importance to all citizens of Greater Winnipeg. Your Committee finds that there are a great deal of data available which, if compiled and made use of, would be of value in explaining many foundation failures and would assist technical men to design new foundations and repair construction satisfactorily.

On the other hand, to answer definitely the three questions asked, a considerable amount of research, observation and experimentation will be necessary over a period of several years. Such a study will naturally require financing and, until your Committee is provided with funds, the suggested study is out of the question.

Your Committee has therefore compiled certain information which is readily available and has condensed it into this Interim Report.

A criticism of this report may be that obtaining a consultant to design and inspect all ordinary house foundations is only adding to the cost of house construction. It is pointed out, however, that the small additional cost of a proper design with adequate inspection during construction of the foundation of the average dwelling is money well spent.

The economic angle of the problem is one which should be given very careful consideration by the general public. Frequently, the owner of a residence or apartment block will hesitate or will absolutely refuse to spend a little extra money to ensure a proper foundation. It is believed that ninety-odd percent of the dwellings in Greater Winnipeg have been built without benefit of technical advice from architect or engineer. The contractor's function is to construct, not to design, so he should not be blamed for faults of design.

In this Interim Report no attempt has been made to formulate general rules which may be applied to all cases. *This cannot be done as every foundation is a problem in itself and must be dealt with as local conditions warrant.*

### Formation of Winnipeg Soils and Sub-Soils

1. The supporting value of soils in different large areas is influenced by their geological formations.

The Winnipeg area is part of the bed of old Lake Agassiz, the great glacial lake which many thousand years ago covered the greater part of Manitoba. There is evidence that this great sheet of water at one time stood at a depth of over five hundred feet above the present city of Winnipeg. Great masses of clay or powdered rock settled to the bottom of this lake and with the melting of the ice barrier and consequent release of the impounded water the site for the future city of Winnipeg was provided.

2. Winnipeg, then, is built on the bed of an old lake. We find between prairie grade and limestone bed rock (which is approximately sixty to seventy feet below) the following typical layers of soil (see Fig. 1), which, however, will vary considerably even over a limited area.

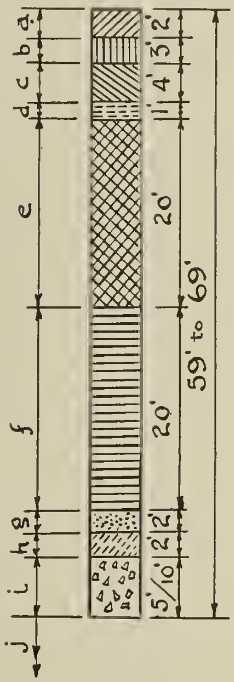


Fig. 1.

(*a*) Roughly two feet of loam with a clay sub-soil, very sticky and plastic when wet. This is the material which appears on the surface of our mud roads.

(*b*) Three feet of material which might be classified as silty clay. This provides a fair foundation for very light structures so long as it retains its moisture. When dried out by drainage or evaporation, however, it becomes brittle and unstable. On the other hand, if saturated with water it becomes plastic and subject to flow and under given conditions it may even be eroded.

(*c*) Four feet or so of brown clay. In its normal state, this is dense and firm, fine grained and practically impervious to the passage of water. Under pressure it is subject to compression and flow and such compression and flow may cause a bulge beyond the limit of the footing. It dries slowly but in the process of dehydration it cracks and shrinks to a considerable degree, and becomes pervious.

(*d*) The so-called "yellow-strip" This is a mixture of clay and silt, bright yellow in colour, which varies in thickness from a few inches to three or four feet. Twelve to eighteen inches is a fair average. It is greatly affected by changes in moisture content. When dehydrated shrinkage is high and the material becomes hard and more or less laminated. If saturated with water it swells and becomes very soft and greasy. In passing it may be stated that this yellow strip has been at least a contributing factor to much of the foundation trouble which has developed in Winnipeg.

(*e*) Approximately twenty feet of dense chocolate-coloured clay. Many buildings in the business area of Winnipeg have foundations in this stratum. Where they have been rationally designed and conservatively loaded and where there has been no undue variation in moisture content of the clay such foundations have, in general, been highly satisfactory.

(*f*) Some twenty feet of dense clay of the type usually known as blue clay. Remarks applicable to (*e*) apply equally to this stratum.

(*g*) Two feet or so of sandy grey material containing a fairly large percentage of ground up limestone and some boulders. Usually this stratum carries water in greater or less degree but rarely in sufficient volume to cause trouble. The bottom of this material is the limit to which an auger boring can be carried.

(*h*) Two feet or more of material somewhat similar to (*g*) but containing a greater percentage of crushed limestone and as a rule embedded boulders ranging in size from ten inches to thirty inches or larger. For want of a better name this material may be classed as semi hard-pan.

(*i*) Five to ten feet or more of hard-pan. This is a very dense material, sometimes described as boulder clay, containing a high percentage of crushed limestone and boulders. It can be excavated with a pick only with considerable difficulty and has about the hardness and consistency of a poor quality concrete. In contact with water, it disintegrates readily.

(*j*) As a general rule limestone bed rock is encountered immediately below hard-pan. Sometimes a layer of water bearing sand, gravel, and decomposed limestone is found. This may provide a heavy flow of water under pressure which in turn may lead to a considerable expense for installation and operation of pumping equipment.

### Foundations for New Buildings

3. There is a feeling, more or less wide spread, that really satisfactory foundations cannot be provided in Winnipeg. *This is not a fact. Satisfactory foundations have been and can be built.* However, the man on the street must face the fact that he, in the final analysis, will get just exactly what he pays for and if he wishes to build a house or an apartment block, he must be prepared to expend a reasonable sum to ensure a foundation which will not cause trouble by uneven or excessive settlement.

4. Very heavy buildings present no particular problem. The best and most economical foundation is a concrete pier (commonly known as

a "caisson") of the requisite size carried to solid bed rock. Examples of such foundations are the Hudson's Bay Store, the Winnipeg Auditorium and the Dominion Public Building.

5. Relatively heavy buildings where foundation loads are not sufficiently great to justify the use of caissons to bed rock have been successfully carried on spread footings in chocolate or blue clay. Such footings must be constructed at a depth sufficient to prevent or minimize dehydration and consequent shrinkage of the supporting clays. Buildings of this type are Canadian General Electric Building, Manitoba Cartage Warehouse, and the Security Storage Building.

6. Another type of foundation suitable for this class of building may be provided by the use of wooden piles driven to refusal at semi hard-pan. As examples may be cited the Wheat Pool Building, and the Nurses Home at St. Boniface Hospital.

7. (*a*) Medium weight buildings such as apartment blocks, schools, etc. have been satisfactorily supported by the deep spread footing as outlined in Paragraph 5. Examples are the Balfouria Apartments, Unit No. 1, River Heights Apartments, and the Royal Canadian Mounted Police Headquarters on Portage Avenue.

(*b*) Wooden piles driven to refusal at semi-hard-pan as described in Paragraph 4 have been also used. Riverbend School is an illustration of this type of foundation.

(*c*) Reinforced concrete piles, auger bored to refusal at semi hard-pan have been used with apparent success on the Dufferin School, Mordue Funeral Home and several structures erected by the Greater Winnipeg Sanitary District.

8. Another type of foundation for such buildings which has considerable possibilities is the thirty-inch caisson, auger bored to or near semi hard-pan and hand excavated and belled out through the semi hard-pan to and into firm hard-pan.

9. The greatest problem of all is encountered in residence construction. The more expensive houses where a little extra money is available can be supported by means of the deep spread footing, the concrete or wooden pile and the small caisson to hard-pan. With few exceptions, however, these methods have not been used for the medium and low cost house. Practically all of such buildings are constructed with spread footings located from four to six feet below prairie level. In other words, the foundations are in brown clay (see Paragraph 2, sub-section (*c*)) or are in or above the so-called yellow strip (see Paragraph 2, sub-section (*d*)). The clays upon which the foundations are supported have within recent years become dried out and laminated to such an extent that immediate settlement takes place. As the drying out process continues, settlement is increased. Further, when the building is completed, the interior foundations are no longer subjected to the direct rays of the sun and the drying out process at this point is retarded. It continues unabated, however, at the exterior walls, particularly those with south and west exposures. The result is a differential settlement which can only end in damaged foundation walls, shattered plaster and partitions, distorted doors and windows and a very appreciable decrease in value.

10. Some improvement has been made by stiffening foundation walls with steel reinforcement, also by stiffening the entire structure by the use of reinforced concrete beams and slabs at the ground floor level. For smaller houses having dimensions up to about 30 ft., beams may span from wall to wall and all interior columns and footings may be eliminated. This transfers the load to the exterior foundation and automatically does away with one of the most potent causes of differential settlement.

11. The stiffening of foundations, however, does not eliminate the fundamental cause of settlement damage, namely, the location of foundations in unstable clay. It may minimize subsequent damage and make for an even settlement but it certainly will not do away with all movement. It would seem, therefore, that the day is not far distant when a better type of residence foundation must be provided either by the use of deep foundations, piles or otherwise. This condition will not come about until the average home buyer realizes that additional foundation security means additional financial outlay.

12. Finally, for all yielding foundations (such as those constructed in clay must of necessity be) the outstanding considerations in design must be the provision of footing units so proportioned that the load per square foot on the supporting clays is uniform and conservative, that the clay itself is uniform and that the live load used in arriving at such proportions is one which may reasonably be expected to apply at all times and not an extreme load which may be in effect for short periods only.

## Causes of Settlement

13. The causes of settlement in buildings are many and varied. Any foundations supported by a compressible material such as clay must of necessity settle to a certain extent. However, if the settlement is not excessive and if it is uniform, no appreciable damage is done. Material settlements due to overloading of the supporting soils and differential settlement due to improper proportioning of footing units and to lack of uniformity in the character of the underlying clay or its moisture content, are those which must be guarded against.

14. The primary cause of settlement in the Winnipeg area is the location of foundations at shallow depths. So long as our clays retained their moisture and so long as non-uniform and excessive soil pressures were avoided, little or no trouble was encountered. During the recent dry years, however, our soils have lost a very great proportion of their moisture. This, in turn, has led to a very material decrease in their volume with accompanying formation of vertical cracks and horizontal laminations. Chocolate or blue clay in its normal condition contains moisture to the extent of 35 to 40 per cent. Today this has in many cases been reduced by more than half, at depths much greater than the average residence or apartment block foundation. The effect of the withdrawal of this amount of moisture and the consequent shrinkage of the clay may readily be imagined.

15. Soil pressures under the average residence are less than a thousand pounds per square foot and under the average apartment block they rarely exceed two thousand pounds per square foot. These pressures are certainly not excessive for clays in their normal state. It has been shown, however, that our clays and particularly their upper layers are today in an abnormal state. It has been further shown that the foundation of the average residence or apartment block is only four to six feet below prairie grade, a depth even less than that of the fatal yellow strip. Settlement of such foundations has therefore been very rapid during the last four or five years.

16. It might be argued that a number of wet years following the recent dry period would restore the clays underlying our foundations to their normal condition. It is submitted that this will not be so. The construction of buildings, pavements, sewers, etc. leads to nearly 100 per cent run-off of rainfall. Even in wet years therefore little moisture finds its way into the sub-soil and the clays are not restored to their former conditions.

17. Certain settlements may be caused by an excess of moisture in localized areas with consequent softening of the upper clays. A defective eaves trough or downspout, a heavy bank of melting snow, or a variety of other factors, may allow water to reach a foundation causing a saturation and softening of the underlying soils, with subsequent differential settlement. This is particularly true if the footing is located in or above the yellow strip or if previous dehydration and shrinkage has provided channels for the inflow of water.

## Repairs to Existing Damaged Construction

18. In the Winnipeg area, underpinning, that is, the addition of new permanent supports to existing foundations, has been on the increase during the last few years. In general, the methods used locally are:—

(*a*) To excavate under existing defective foundations and to build a larger footing at a greater depth; supporting the existing footing on the new one through an additional foundation wall constructed between the old and new footings. This might be defined as under-mining rather than underpinning. When the load of the building is transferred to the clay under the new footing such clay is subject to immediate compression and further settlement takes place. This type of underpinning may therefore serve to accentuate the previous settlement.

(*b*) The method outlined in (*a*) in addition to "pretesting," that is, the use of jacks between the existing building and the new footing to force the latter downward, thereby compressing the underlying soil. Supporting walls or piers are constructed between old and new footings before removal of jacks. The jacking action removes the objection outlined for (*a*) but a considerable period must elapse to permit a proper compression of the newly loaded clay. This system is therefore slow in its construction.

(*c*) To bore under the existing footing to semi hard-pan by means of an auger thirteen inches to twenty-two inches in diameter or larger and to fill the resulting shafts with concrete, reinforced with steel rods. This method is usually described as the cast-in-place concrete pile system.

(*d*) The method outlined in (*c*) but making use of an auger thirty inches in diameter or larger. Boring is stopped at or slightly above semi hard-pan, after which excavation is carried further by hand labour until the solid hard-pan is reached. The bottom of the shaft may be belled out to provide additional bearing area on hard-pan. After completion of excavation, shafts are filled with concrete.

(*e*) Hand excavated concrete filled caissons to hard-pan or rock. If stopped at hard-pan the bottom may be belled to carry the required load at seven or eight tons pressure on the hard-pan. If carried through to bed rock, a pressure of thirty tons per square foot may be used.

(*f*) Methods (*a*) and (*b*) have today been largely superseded by (*c*) and (*d*) and occasionally (*e*).

## Field Tests and Other Work Suggested for the Consideration of The Institute

19. It has been shown that satisfactory foundations can be secured in clays if the information now at the disposal of the engineering, architectural, and construction fraternities is utilized. It is considered therefore that tests of bearing capacities of clays will serve no useful purpose at this stage. It is suggested, however, that valuable data can be obtained by setting up an organization to make periodic check levels on existing and new buildings with a view to determining the rate and extent of their settlement. Some work of this nature is now being done by certain firms and individuals but this of necessity can be of a very limited nature.

20. Few loading tests have been performed on concrete or wooden piles and none at all on caissons to hard-pan. Further, there is a certain amount of controversy amongst engineers and others as to the interpretation of data available on the allowable loads for various sizes of piles, also as to the means whereby a pile sustains a load, whether by skin friction, by point bearing, by bulb of pressure, etc. Another question on which no data are available is the relation between the carrying capacity of a single pile and that of a group of piles. It is suggested therefore that a really comprehensive series of tests be carried out on single piles, on groups of piles and on caissons to hard-pan and that such be made in various parts of the Greater Winnipeg area.

21. Various firms and individuals have considerable data on file regarding the depth and character of the soil formation over the Winnipeg area. This should be collected and compiled.

22. Much valuable information could be obtained by excavating a number of test pits in various parts of the city. A study should be made and a record compiled of the character of the excavated materials, their moisture content, etc.

23. Another question worthy of attention is the cause and prevention of heaving or upward movements of concrete basement floors.

24. Laboratory studies might be made at the University of Manitoba and in other laboratories suitably equipped for such work. Such studies would provide data regarding mechanical, physical, and chemical characteristics of our soils.

### Summary

Summarizing the foregoing it may be stated that:—

1. Excellent foundations can be obtained for heavy buildings by the use of caissons to bed rock.

2. Extending foundations to such depths for dwellings and moderate weight buildings is not economically practicable.

3. The upper soil strata in Greater Winnipeg are unstable and great care should be exercised in designing foundations, even for ordinary dwellings.

4. Sufficient information is already available for reasonable security in designing foundations for dwellings and moderate weight buildings.

5. Experience and technical knowledge is imperative for such designs.

6. Due to variations in soil formation each foundation is a separate problem.

7. It is desirable to make the cost of technical advice on dwelling foundations as small as possible so that construction costs will not be prohibitive.

8. Much is already known about how piling of wood or concrete can be used successfully in foundation work.

9. Less is known as to the *sustained* carrying capacity of individual piles and groups of piles, particularly in Winnipeg soils.

10. Other factors among many worthy of further investigation are:—

(*a*) The effect of ground water or the lack of it, on piling of wood or concrete.

(*b*) The effect on foundations of raising and lowering the water level of our two rivers.

(*c*) The possibilities of stabilizing soils by saturation chemical action, etc.

### Recommendations

The following recommendations are made:—

1. That the public be given more information on foundation problems in the Greater Winnipeg area.

2. That even those intending to build dwellings or other relatively low cost structures, be advised to employ technical consultants on the design and supervision of construction of foundations.

3. That research work on foundation problems both in the field and laboratory be carried on and that funds be raised for this purpose.

Recommendation 3 has been amended to read:—

That research work on foundation problems both in the field and in the laboratory be carried on and that the raising of the necessary funds (estimated at $40,000) for this purpose be investigated.

### Committee on Foundations in Winnipeg—1937

A. E. Macdonald, M.E.I.C., *Chairman*,
Professor, and Head of the Department of Civil Engineering,
University of Manitoba.

W. F. Riddell, M.E.I.C., *Vice-Chairman*,
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| Members | Representing |
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| H. B. Henderson, M.E.I.C., Cowin & Co., Structural Engineers.<br>A. J. Taunton, M.E.I.C., Professional Engineer.<br>T. C. Main, A.M.E.I.C., Engineer, Water Supply, Canadian National Railways. | Representing the Winnipeg Branch, The Engineering Institute of Canada. |
| E. S. Kent, A.M.E.I.C., Cowin & Co., Structural Engineers.<br>D. L. MacLean, A.M.E.I.C. Assistant Chief Engineer, Greater Winnipeg Sanitary District.<br>W. Aldridge, Assistant City Engineer, City of Winnipeg.<br>W. D. Hurst, A.M.E.I.C. Assistant Engineer, City of Winnipeg. | Representing the Association of Professional Engineers of the Province of Manitoba. |
| H. H. G. Moody, Moody & Moore, Architects.<br>C. W. U. Chivers, Northwood & Chivers, Architects.<br>L. Green, Green, Blankstein, Russel & Ham, Architects. | Representing the Manitoba Association of Architects. |
| A. Blackie, National Testing Laboratories Ltd. | Representing the Manitoba Branch, Canadian Institute of Chemistry. |

*Courtesy Editorial Association, Montreal*

**General View of the Ontario Paper Company Development at Baie Comeau, Que.**

# RECENT ADDITIONS TO THE LIBRARY

### Proceedings, Transactions, etc.

American Society for Testing Materials: Year Book, August 1937.
Institution of Electrical Engineers: List of Members 1935.
Institution of Mechanical Engineers: Proceedings, Vol. 135, Jan-May, 1937.
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Collisions in Street and Highway Transportation by Barry Mulligan, 1936. (*Dorrance and Company Inc., Phila.*)
Deutsch-Russishes Worterbuch fur Zementindustrie, 1936. (*All Union Research Institute of Leningrad.*)
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The Theory of Continuous Structures and Arches by Charles M. Spofford, 1937. (*McGraw-Hill, New York.*)

# BOOK REVIEWS

## Handbook of Chemistry

*Compiled and edited by Norbert Adolph Lange, Ph.D., Handbook Publishers, Inc., Sandusky, Ohio, 1937. 1,802 pages, 5⅝ by 7¾ inches, fabrikoid, $6.00.*

A complete and handy reference volume for those requiring chemical and physical data and while principally of value to the chemist or student of chemistry it should also prove most useful to physicists, mineralogists, engineers and librarians.

The book contains some 1,800 pages including 250 pages of mathematical data and tables and an index of more than 2,700 entries.

This second edition while following the same pattern as the first contains new tables and changes to a large number of others to bring them up to date. New material includes sections on organic ring systems, formula index and melting points of organic compounds, 160 pages on refractive indices, formulae of denatured alcohols and authorized uses and 6 pages in the appendix on probability functions and factors.

The binding is of durable fabrikoid and the size, style of type and arrangement of tables makes reference work easy and reading accurate.

## Man in a Chemical World

*By A. Cressy Morrison, Charles Scribner's Sons, New York, 1937. 292 pages, 9 by 6½ inches, cloth, $3.00.*

In this book, which was written in connection with the American Chemical Industries Tercentenary, the 300th anniversary of the founding of chemical industries in America, the author presents a fascinating account of the usefulness of the chemical industry to the people of the United States.

It is intended to be educational, its object to impress the man in the street with the fact that the chemical industries render a service that touches practically all activities and to what extent he is dependent upon these industries.

Mr. Morrison in this volume has departed from the story that has been told for the last twenty years, that chemistry is the key to modern civilization and the hope of the future, and the reader will find an informative story of how this industry contributes to life's necessities such as food, clothing, medicine, transportation, communication, shelter, social security and luxuries.

There is little of historical matter or of the future and both the engineer and the non-technical man will find this book full of practical informative and worthwhile reading.

## How to Make Alignment Charts

*By Merrill G. Van Voorhis, McGraw-Hill Book Company, New York, 1937. 114 pages, 9 by 6, cloth, $2.50.*

The author who has had experience in presenting a course of nomography to technical men has drawn up and presented his material for this text to suit the requirements he has found most necessary.

The purpose of the volume is to provide instruction on how to make nomographic or alignment charts for the solution of engineering and other formulae. Stress has been placed on how to handle various types of equations. Graphical construction methods are described when practical along the mathematical method. Of the two theoretical approaches to the subject in general use, the author favours that by plane and analytical geometry in preference to that by the determinants.

A list of general type equations, nineteen in number, is included and some forty-four formulae have been charted. The theory of construction, which is in not essential to the making of the charts, is confined to the appendix where it is briefly outlined for reference purposes.

The text of this work is well treated, the simplest formulae being treated first and as groups of equations are described, their relation to each other and to certain type forms become obvious.

# BULLETINS

*Tractors.*—A 16-page pictorial bulletin by the Cleveland Tractor Company, Cleveland, Ohio, shows their crawler tractors in operation in every corner of the world. (Form No. 822.)

*Groov-Pins.*—Groov-Pin Corporation, Union City, N.J., describe their groov-pins and drive-studs in a 16-page illustrated catalogue.

*High-Pressure Pumps.*—Worthington Pump and Machinery Corporation, Harrison, N.J., announces, in a 6-page bulletin, the development of a new pump designed for high-pressure boiler feed and gathering service in the oil fields. (Bulletin W-103-B3.)

*Flat-Rolled Steel.*—The American Institute of Steel Construction has published a 35-page illustrated booklet of an address, "Light-Gage Flat-Rolled Steel in Housing," by F. T. Llewellyn, research engineer, United States Steel Corporation, October 1937.

*Excavators.*—Priestman Brothers Limited, London, Eng., show photographs of their excavators, dredgers and grabs in a 6-page bulletin.

*Water Heaters.*—A. Reyrolle and Company, England (representatives: Northern Electric Company), have issued a 12-page circular on medium voltage electrode water-heaters and an 8-page circular on metal-clad medium-voltage immersion-heater banks with totally-enclosed connectors for thermal-storage building-warming domestic hot-water supplies and other industrial applications.

## Expansion Programmes of Canadian Power Firms

Capital outlay by the major Canadian power systems for 1937-38 will aggregate about $20,000,000 while work planned to be completed in the next year totals another $25,000,000. A further outlay of $10,000,000 is anticipated on transmission and distribution line work. These returns from 17 major power systems in all parts of the country indicate their expansion to meet the demand for electrical service.

These returns, by provinces, represent 80 per cent of the new capital expenditure:

| | |
|---|---|
| Nova Soctia | $ 1,727,000 |
| New Brunswick | 350,000 |
| Quebec | 28,575,000 |
| Ontario | 11,745,000 |
| B.C. | 1,500,000 |
| Prairies | 129,000 |

A large proportion of the planned outlay covers new developments. Shawinigan Water and Power Company and Brown Corporation are carrying out, over a period of two years, a $15,000,000 plant development at La Tuque, P.Q. The Quebec Power Board have $10,000,000 to spend for the supply of power in districts at present without electrical energy. With hardly an exception all the companies listed below are expanding their systems in order to open up new territories.

| Company | Capital Outlay | Remarks |
|---|---|---|
| Shawinigan | $ 750,000 | Sub station at Three Rivers. |
| St. Maurice Power* | 15,000,000 | Plant of 150,000 hp. at La Tuque, P.Q. |
| Quebec Power Board | 10,000,000 | Not allocated; to be used in setting up Provincial Hydro. |
| Saguenay Power | 450,000 | Isle of Maligne Unit. |
| Seaboard Power | 300,000 | Steam generator 7,500 kw. |
| B.C. Power | 1,500,000 | 47,000 hp. unit. |
| Montreal Power | 300,000 | Sub station; distribution lines. |
| N.S. Power Board | 1,360,000 | 5,200 hp. unit on Mersey river. |
| Ontario Paper | 2,000,000 | Balance of expenditure on power plant at Outardes Falls. |
| Canada Northern | 1,145,000 | Distribution lines. |
| Ontario Hydro | 1,600,000 | New plant developments. |
| | 2,500,000 | Transmission lines. |
| | 3,500,000 | Rural and distribution feeders. |
| | 3,000,000 | Transformer stations. |
| Gatineau Power | 75,000 | Distribution lines. |
| N.B. Power Board | 350,000 | $75,000 on plant; balance distribution. |
| Eastern Light | 67,000 | Distribution lines. |
| Dominion Electric | 42,000 | Distribution and plant. |
| National Light | 87,000 | Transmission lines. |
| West Kootenay | | Maintenance; charged to current income; no capital outlay. |

*Joint undertaking at Shawinigan and Brown Corp. at La Tuque.

—*Financial Post.*

*The Canadian General Electric Company Limited* have just issued a new 572-page Wiring Materials Catalogue which includes a forty-page introductory section added to help electrical contractors sell adequate wiring. Complete up-to-date listings of wiring materials and accessories, and a bilingual introductory section in catalogues for the province of Quebec, makes this catalogue one that will be extremely interesting to electrical contractors and electrical departments of mines and industrial plants.

Copies may be obtained on request to the C-G-E office nearest you.

# BRANCH NEWS

## Edmonton Branch

*M. L. Gale, A.M.E.I.C., Secretary-Treasurer.*
*F. A. Brownie, Jr.E.I.C., Branch News Editor.*

Members of the Edmonton Branch of The Institute met at a luncheon in the Jasper room of the Macdonald hotel on Saturday, August 28th, 1937. The guest speaker on this occasion was G. J. Desbarats, C.M.G., Hon.M.E.I.C., President of The Institute, who spoke briefly on Institute matters.

He referred to the splendid success of the semicentennial meeting held this year and outlined briefly the present state of the negotiations with regard to the relationships between The Institute and the provincial associations. Mr. Desbarats spoke emphatically of the necessity of more active participation by members in Institute affairs and also suggested that members make greater use of head office facilities.

On the meeting being adjourned by the chairman, Mr. J. D. Baker, there followed an informal period in which members had an opportunity of meeting the President personally.

At 4 o'clock the members drove to a newly developed park at the city power plant where they joined with other engineers and civic officials in a brief, impressive ceremony in which Mr. Desbarats dedicated a memorial sundial to the late William John Cunningham, A.M.E.I.C.

Mr. Cunningham was superintendent of the Edmonton Power Plant for many years and during that time had left no doubt as to his skill as an engineer and his fine qualities as a citizen and friend.

To many of those present, as the President unveiled this beautiful little memorial of stone and brass, there was recalled the deep sense of personal loss they had experienced in the passing of this brother engineer.

## Montreal Branch

*E. R. Smallhorn, M.E.I.C., Secretary-Treasurer.*

JUNIOR SECTION BRANCH VISIT

On Saturday afternoon, October 2nd, 1937, the Junior Section of the Montreal Branch were permitted, through the kindness of the officials of the company, to visit the plant of the Noorduyn Aircraft Limited at St. Laurent, P.Q.

This was a particularly interesting inspection trip as the company manufactures the Norseman and Beechcraft lines of aircraft and employs some one hundred and fifty men. Technical information was provided by the company's engineering staff and some one hundred and twenty-five members of the Junior Section attended.

FOREST INDUSTRIES IN THE ECONOMIC LIFE OF QUEBEC:

At the first fall meeting of the Montreal Branch, held on October 7th, Lt.-Col. L. J. D. Marquis, chief of the Department of Forest Products with the Department of Land and Forest of the Province of Quebec, gave an address on the part played by the forest industries in the economic life of the Province of Quebec.

An interesting discussion followed, which was led by Mr. G. C. Piché, formerly chief of the forest service of Quebec.

The evening's entertainment was terminated by the showing of motion pictures of lumbering operations in British Columbia. These were presented by Mr. Archie Moore, manager of the British Columbia Lumberman.

Refreshments were served at the conclusion of the meeting. Prior to the meeting an informal dinner was held at the Windsor hotel.

Huet Massue, A.M.E.I.C., acted as chairman.

JUNIOR SECTION

"The Engineer as the Citizen" was the subject of an address given before the Junior Section on October 13th by David Boyd, A.M.E.I.C., who is on the engineering staff of the Canadian Car and Foundry Company Limited, Montreal. Mr. Boyd's address was an excellent and thought-provoking discussion which pictured the engineer as a private citizen and the part he should take in public and private life and also in his relations with government, labour and the public generally.

Refreshments were served at the close of the meeting.

C. E. Frost, A.M.E.I.C., was in the chair.

INDUSTRIAL RESEARCH

On October 14th, Dr. L. W. Chubb, Director of Research of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, discussed the part that research plays in engineering achievement. His address was an excellent presentation of some of the more dramatic engineering developments and scientific improvements. Exceedingly interesting demonstrations were made during Dr. Chubb's discussion.

Members of the Institute of Radio Engineers were guests of the Branch. Prior to the meeting an informal dinner was held at the Windsor hotel.

Chairman: C. J. DesBaillets, M.E.I.C.

## Peterborough Branch

*W. T. Fanjoy, A.M.E.I.C., Secretary-Treasurer.*
*J. L. McKeever, Jr.E.I.C., Branch News Editor.*

The Peterborough Branch of The Institute held their annual outing on Saturday, September 25th, 1937, at the Kawartha Boys, Camp on Clear Lake. A programme of sports had been arranged by a committee under Mr. B. I. Burgess, the main item of which was a softball game. This game, and particularly the prowess exhibited by "Babe Ruth" Cruthers and "Dizzy Dean" Fanjoy, proved to be of such interest to the horses and cattle for miles around that the game had to be halted to drive them (the horses and cattle) off the diamond. After six innings, one side gave up the struggle, so after a brief respite the teams were again pitted against each other in a nail driving contest which ended in a riot upon the discovery that someone had "driven" a nail into an open knot-hole. The final sport event was a buck-saw

Members of the Peterborough Branch at Clear Lake, Ont.

contest which showed up the degeneracy of the modern youth who has learned only to turn a switch on the electric range instead of to cut wood for a fire.

By this time all were ready to enjoy the very satisfying supper set out in the camp dining hall, after which the camp director, Mr. McClenaghan, led the party in some action songs. The Branch chairman, Mr. V. R. Currie, then called upon our oldest member, Mr. W. A. Logan, who was celebrating his 86th birthday the next day, to tell one of his baseball stories. Before telling his story, Mr. Logan gave an interesting account of a survey of the Clear Lake and Stoney Lake regions in which he took part some fifty years ago. Finally, Mr. Currie moved a very hearty vote of thanks to Mr. McClenaghan and his staff, and the outing was brought to a conclusion by the singing of the National Anthem.

## Design of Elevated Highways Competition

Traffic accidents and congestion constitute one of the most serious problems confronting the United States today. An annual toll of 37,000 fatalities, 125,000 permanent disabilities and 1,200,000 personal injuries creates a social situation demanding solution. Rapidly growing congestion, especially in cities, is an obstacle to efficient production and distribution, in general, and greatly depreciates the tremendous investment in automotive equipment of all kinds.

Leading traffic authorities have been forced to the conclusion that the only permanent solution of this joint problem of accidents and congestion is through the construction of major traffic routes particularly adapted to the operating characteristics and potentials of the automobile. Thus, they have projected a type of highway design to have the following physical and operating features:

1. It provides for a complete physical separation of streams of traffic moving in opposite directions.
2. It eliminates any direct access to abutting property.
3. It provides for an elimination of all intersections through a complete and continuous separation of grades.
4. It provides decelerating lanes for vehicles slowing to leave the highway at specially provided exits and accelerating lanes for vehicles entering from specially provided entries.

Traffic routes of this type of construction have already demonstrated their ability to carry safely large volumes of traffic through congested districts at open highway speeds. Several cities are now projecting comprehensive systems of this type and many others will undoubtedly follow.

An analysis of physical and fiscal elements leads to the conclusion that the essential functions of this special highway design can be achieved most practically and economically through elevated construction. To stimulate interest in this programme, which holds such great promise for the permanent solution of urban traffic problems, the American Institute of Steel Construction is sponsoring a competition for design of a structure of this type.

### Eligibility

Any person, persons or firm, with the exception of staff members of the American Institute of Steel Construction, may enter the competition and submit designs. The competition is open to persons of all nationalities and to amateur as well as to professional designers and architects. Those intending to enter the competition should notify the American Institute of Steel Construction immediately. There are no entry fees, and competitors may submit one or more designs. Each design will be considered a separate entry.

The competition will continue until March 31st, 1938, by which date all designs submitted by competitors must be in the hands of the American Institute of Steel Construction.

### Awards

Sole authority for the making of awards shall rest in a Jury of Award consisting of seven members as follows: Harland Bartholomew, City Planner, St. Louis; Col. Willard Chavalier, President, American Road Builders Association, Vice-President, McGraw-Hill Publishing Company, Inc., New York; Paul P. Cret, Architect, Philadelphia; Loran D. Gayton, City Engineer, Bureau of Engineering, Department of Public Works, Chicago; Paul G. Hoffman, President, The Studebaker Corporation, South Bend, Ind.; Albert Kahn, Architect, Detroit, and C. M. Pinckney, Chief Engineer, Borough of Manhattan, New York.

In submitting designs competitors must agree to abide by the decision of this Jury of Award.

The awards shall be as follows: First prize, $5,000; second prize, $2,000; third prize, $1,000; and ten honourable mention awards, each $100.

### Conditions

Each competitor shall submit drawings showing both structural and architectural treatment of an elevated highway structure. Two or more persons may jointly be a competitor. The designs shall be of such a character and of such detail as to be readily interpretable by a person normally familiar with structural and architectural design and may or may not be accompanied by a description.

The object of this competition is to develop a technique of design suitable to elevated highways. The competition will be judged on the originality of design, practicability of construction, the economical use and arrangement of materials, adaptability to actual conditions, and beauty. Designers may feel free to use new methods of design, new materials, and colour if they so elect.

Each design must incorporate all of the physical and operating features of elevated highway construction as previously set forth in this announcement.

The following technical conditions shall control the designs:

1. The structure shall be designed for an "H-20" loading, as a maximum, but any competitor may design for the exclusive use of passenger automobiles based upon such load factors as he may propose, provided that one "H-20" truck shall be assumed to be on any one span, with a congested load of passenger automobiles. The actual size of steel members need not be given. The loadings are given merely as a guide for proportioning materials and fixing construction limits.

2. The design shall provide for two eleven-foot operating lanes in each direction, physically separated and with adequate outer guard rails, but any competitor may submit additional designs providing for three or more operating lanes in each direction.

3. The structure shall be designed to be built over existing thoroughfares. Any type of support may be used, provided, however, that if supports are placed in existing roadways they must not interfere with the free flow of surface traffic. The competitor may pick out some actual site in his own community and develop a design to meet actual conditions.

4. Structures designed to pass over existing surface traffic shall provide for a free and unobstructed clearance of fifteen feet between the bottom of the elevated structure and the pavement of the street below.

All structural members shall be of steel. Other parts may be of any material suitable to the design.

Each competitor shall submit two drawings for each separate entry. Each drawing is to be 20 in. by 32 in., which shall include a half inch margin on all sides. The drawings are to be mounted on stiff board.

The first drawing shall be used for a perspective sketch or a plain elevation drawing of the proposed structure. There shall be no figures, dimensions, or written descriptive matter on this drawing other than the title.

The second drawing shall consist of an elevation covering at least one span and a cross section showing the supports and showing the provisions for ingress and egress drawn at a scale of one-eighth inch to the foot. There shall also be drawn at the same scale a cross section at the centre of the span to describe the construction. Such details as may be necessary are to be drawn at a scale of three-quarters of an inch to the foot. Dimensions, design data, size and kinds of material and other written descriptive matter may be used on this drawing.

Signatures will be concealed by the Institute until the jury has completed its selections.

Drawings must be sent to the American Institute of Steel Construction, V. G. Iden, Secretary, 200 Madison Avenue, New York City, not later than March 31st, 1938.

# EMPLOYMENT SERVICE BUREAU

The Service is operated for the benefit of members of The Engineering Institute of Canada, and for industrial and other organizations employing technically trained men—without charge to either party.

*All correspondence should be addressed to*

**The Employment Service Bureau, The Engineering Institute of Canada**
**2050 Mansfield Street, Montreal**

## Situations Vacant

YOUNG MECHANICAL ENGINEER, for sales and service work, for an established company selling specialized product. Location Montreal. Apply to Box No 1681-V.

YOUNG ELECTRICAL ENGINEER, with some experience in electrical design and draughting. Location Montreal. Apply to Box No. 1683-V.

MECHANICAL DESIGNER, experienced in machine design. Must also be a good draughtsman, for manufacturing plant in Montreal. Permanent position. Apply at once to Box No. 1684-V.

YOUNG ELECTRICAL ENGINEER, for sales position in Montreal and vicinity. Must speak French and English. Apply to Box No. 1485-V.

THE NATIONAL RESEARCH COUNCIL OF CANADA, announces two vacancies in the division of chemistry. One for a Junior Research Chemist at a salary of $2,100 a year, and the other for a Senior Research Assistant at a salary of $1,620 a year. Full information may be secured through the Employment Service Bureau of The Institute.

## Situations Wanted

PURCHASING ENGINEER, graduate mechanical engineer, Canadian. Married, with fifteen years experience covering construction and operation, principally having to do with specification and ordering of equipment and materials for new construction and maintenance. Details upon request. Apply to Box No. 161-W.

INDUSTRIAL ENGINEERING EXECUTIVE, with wide experience including fourteen years in design, construction, maintenance and operation of pulp and paper mills and power developments. Now employed, desires change of location. Apply to Box No 320-W.

STEAM POWER PLANT DESIGNER, with wide experience will be available after Dec. 1st. next, on completion of a six hundred and fifty pound pressure steam-electric plant now going into service. Apply to Box No. 525-W.

CIVIL ENGINEER, B.A.Sc., age 44, structural, harbour, executive. At present designing 32,000-h.p. development in Newfoundland. Available in near future. Apply to Box No. 536-W.

DOMINION LAND SURVEYOR, and graduate engineer with extensive experience on legal, topographic and plane-table surveys and field and office use of aero-photographs, desires employment either in Canada or abroad. Available at once. Apply to Box No. 589-W.

ELECTRICAL ENGINEER, B.Sc., E.E., age 38. Married. Ten years electrical experience; including, one year operation, one year maintenance, and four years on construction of hydro-electric plants and sub-stations. Four years electric maintenance and construction in pulp and paper mill. Also experience on highway construction and Geological Survey. Available at once. Apply to Box No. 636-W.

ELECTRICAL ENGINEER, B.Sc. E.E. '28. Two years with large electrical manufacturing company including test course, about two years in supervisory operating office of a large electrical power utility, and considerable experience in electrical and mechanical draughting. Location in Ontario preferable. Apply to Box No. 660-W.

YOUNG CIVIL ENGINEER, B.Sc. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

CIVIL ENGINEER, B.Sc., M.Sc., R.P.E.; Lieut. C.E., R.O. 16 years municipal, highway and construction, 5 years overseas. Married. Read, write and talk French. Will go anywhere. Apply to Box No. 737-W.

ELECTRICAL ENGINEER, B.Sc. '31, Jr.E.I.C. Single. One and a half years with contracting firm installing power and lighting equipment. Four years supervision over service and sales staff of electrical and radio company. Draughting and designing experience in power and compressed air layouts. Estimating and designing for electrical and mechanical layouts desired. Available on short notice. Apply to Box No 740-W.

## Situations Wanted

CIVIL ENGINEER, S.E.I.C., B.Sc. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman, compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

MECHANICAL ENGINEER, Jr.E.I.C., technical graduate, bilingual, age 35, married, experience includes five years with firm of consulting engineers, design of steam boiler plants, mechanical equipment of buildings, heating, ventilating, air conditioning, plumbing, writing specifications, etc. Five years with large company on sales and design of power plant, steam specialties and heating equipment. Available on short notice. Apply to Box No. 850-W.

STRUCTURAL ENGINEER, B.A.Sc., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

ELECTRICAL ENGINEER, B.Sc. (McGill '28), age 34. Experience includes transmission line and rural distribution construction and design. Some installation of motors and equipment, also house wiring. Available immediately. Apply to Box No. 940-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No 1021-W.

ELECTRICAL ENGINEER AND GEOPHYSICIST, B.Sc. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No 1168-W.

ELECTRICAL ENGINEER, B.Sc. '34 (Univ. of N.B.), S.E.I.C. Age 24, single. Desires any kind of electrical work. Will consider any location. Apply to Box No 1262-W.

ELECTRICAL AND RADIO ENGINEER, S.E.I.C., B.Sc. (Elec.) '32, M.Sc. '34. Experience includes four years part time operator for radio broadcast station, repairs to radio receivers and test equipment, design and construction of amplifiers and inter-office communication systems. Available on short notice. Apply to Box No. 1283-W.

CIVIL ENGINEER, M.E.I.C., R.P.E., married, age 40. Twenty-two years experience in detail, design, estimating and cost accounting of buildings, bridges, tanks and all types of structures; organization and management. Apply to Box No 1367-W.

CIVIL ENGINEER, B.Sc. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No 1470-W.

## Situations Wanted

CONSTRUCTION SUPERINTENDENT, M.E.I.C. Age 49. Married. Twenty-two years experience as engineer, superintendent and manager in charge of hydro-electric, mechanical production, structural steel erection, also considerable experience in steam plants, combustion, transmission lines, millwright work, complete mine installations, rock work, rock crushers and conveyors. Executive ability. Speaking French fluently. Location immaterial. Apply to Box No. 1482-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.Sc. '31 (Univ. of Alta.), Jr.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switch-gear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work, location immaterial and available at once. Apply to Box No 1522-W.

CIVIL ENGINEER, B.Sc. '32, S.E.I.C., P.E.N.B., D.L.S.N.B., age 32. Experience in mining, both coal and metals, private and legal surveys, railroad construction, geology and building construction. At present in private practice in coal mining district. Desirous of changing location for position either in mining field or construction in Canada or abroad. Apply to Box No. 1562-W.

RESIDENT ENGINEER, familiar with all types of surveys and construction work including, railway, roads, irrigation, drainage, buildings and air ports. Executive ability. Had charge of several large projects. Intimate knowledge of reports and estimates. Available immediately. Any location. Apply to Box No 1567-W.

CIVIL ENGINEER, B.Sc. '17, O.L.S. Married. Executive and administrative experience. Extensive office and field experience in harbour works, dredging; both steam and electric railways in location, construction and maintenance; telephone works in design, construction and maintenance of pole lines, wire, cable and conduit; highways in location, construction and paving; municipal works in roads, sidewalks, sewers and water mains. Intimate knowledge of estimating, unit costs, cost accounting and analysis. Some knowledge of air conditioning. Willing to locate anywhere. Available at once. Apply to Box No 1587-W.

ELECTRICAL ENGINEER, B.Sc '27 (McGill), A.M.E.I.C. Age 36. Married. Bilingual. Three years experience in telephone work (installation of manual and automatic exchanges). One year electrical prospecting. Nine years experience with electrical power company. Apply to Box No. 1601-W.

CHEMICAL ENGINEER, graduate McGill '36. Eight months experience in commercial laboratory of large industrial plant. Knowledge of coal chemistry and boiler water treatment. Also some experience in pulp and paper control work. Location immaterial. Apply to Box No. 1617-W.

CIVIL ENGINEER, B.Sc. in C.E., A.M.E.I.C. Age 32. Married. Three years of pulp and paper mill experience, draughting, instrumentman and maintenance. One year as instrumentman on highway construction. Five years checking and designing reinforced concrete and steel. Apply to Box No. 1658-W.

ENGINEER, age 44, seeks connection as chief or plant Engineer, with pulp and paper, or textile concern. Apply to Box No. 1662-W.

METALLURGICAL ENGINEER, graduate 1936. Experienced in gold smeltering and milling, also in steel and pig iron manufacturing. Desires new connection in eastern Canada or Great Britain. Apply to Box No 1673-W.

ELECTRICAL ENGINEER, B.A.Sc., U. of T. '24, A.M.E.I.C., single, age 44. Ten years in supervisory operating office and two years in construction division (office and field) of large city electrical utility commission. One year factory supervision and tool design in manufacture of small electrical equipment. Wide experience with internal combustion engines. Experience handling heavy machinery. Private pilot's license for light aircraft. Full details on request. Available on short notice. Apply to Box No. 1693-V.

MECHANICAL AND ELECTRICAL ENGINEER, age 47, graduate University of Toronto, 1911. Machinist's trade. Two years tool design and quantity production in the U.S.A. Twelve years Canadian shop experience design and producing heavy equipment. Twelve years as chief sales engineer and field man for one of the largest Canadian national concerns. Experience in manufacturing and sales of pumps, engines, paper mill equipment, power plant equipment and specialties, electrical machinery, etc. Clean record, excellent connection. Apply to Box No. 1699-V.

ELECTRICAL ENGINEER, B.Sc., E.E. (Univ. of Man. '37). Experience in highway construction as inspector. Available at once. Apply to Box No. 1703-W.

# Preliminary Notice

## of Applications for Admission and for Transfer

October 27th, 1937

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.*

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

The Council will consider the applications herein described in December, 1937.

R. J. Durley, Secretary.

*The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years in the case of a candidate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of age, and shall have been engaged in some branch of engineering for at least six years, which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch of engineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more years.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard.

**A Student** shall be at least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.

### FOR ADMISSION

BALLOU—FREDERICK H., of Vancouver, B.C., Born at Independence, Iowa, U.S.A., July 30th, 1884; Educ., Mech. Engr., Stevens Institute of Technology, Hoboken, N.J., 1908. R.P.E. of Alta.; 1908-16, ap'tice, dftsman. and engr., and 1916-20, asst. chief engr., i/c of Montana Divn. at Billings, Mont., for Greater Western Sugar Co., Denver, Colorado; 1920-22, chief engr., The Amalgamated Sugar Co., Utah; 1922-24, chief engr., W. J. McCahan Sugar Refining & Molasses Co., Philadelphia, Pa.; 1924-30, chief engr., American Beet Sugar Co. (now the American Crystal Sugar Co.), Denver, Colo.; 1931 to date, chief engr., B.C. Sugar Refining Co. Ltd., Vancouver, B.C., and Canadian Sugar Factories Ltd., Raymond, Alta.
References: J. Robertson, A. S. Gentles, P. M. Sauder, R. S. Trowsdale, G. H. Thompson, R. Livingstone, G. A. Walkem, E. A. Wheatley.

BOISMENU—ROMEO, of Hawkesbury, Ont., Born at Montreal, June 22nd, 1899; Educ., 1920-22, Ecole Polytechnique, Montreal, completed first year engrg. course; R.P.E. of Quebec by Exam., 1930; with the Technical Service, City of Montreal, 1922-24. 1922 as chainman. and in June 1931, named as engr., and from this date engaged in the preparation of plans and profiles of streets for different kinds of works, such as pavement, sidewalk and sewer; 1934-35, private practice, estimate of cost bldgs. (steel, concrete and wood), estimate of cost roads (contractors), etc.; 1935-37, chief engr. for H. Marchessault & Co., on roads, excavation and levelling, concrete bridges, design and constrn.; 1937, divn. engr. (resident), Quebec Provincial Highways Dept.; at present, supt., Town of Hawkesbury, Ont.
References: G. R. MacLeod, J. G. Caron, J. F. Rutherford, A. Mailhiot, O. O. Lefebvre, E. Brown.

CAMERON—ALAN EMERSON, of Halifax, N.S., Born at London, Ont., Oct. 18th, 1890; Educ., B.Sc., 1913, M.Sc., 1914, McGill Univ. D.Sc., Mass. Inst. Tech., 1926; 1909-10, rodman, Nat. Trans. Rly.; 1911, topographer, Hudsons Bay Rly.; 1912-14, Geol. Survey of Canada; 1918-19, overseas. Lieut., Can. Engrs.; 1914-21, lecturer in mining, 1921-26, asst. professor of mining, 1926-37, professor of metallurgy, University of Alberta. Also professional engineering, mining, metallurgy and geology. Secretary—Research Council of Alberta; at present, Deputy Minister of Mines, Prov nce of Nova Scotia, Halifax, N.S.
References: R. W. Boyle, R. S. L. Wilson, H. J. MacLeod, E. Stansfield, C. A. Robb.

CARTER—WILLIAM FRANKLIN S., of 119 Arlington Ave., Westmount, Que., Born at Winnipeg, Man., March 21st, 1914; Educ., B.Eng., McGill Univ., 1936; 1932 (summer), asst. to assayer, Siscoe Gold Mines; 1934 (summer), gen. engr., Tiblemont Island Mining Co. Ltd.; 1935 (summer), experimental dept., Ingersoll-Rand Co., Painted Post, N.Y.; 1936 to date, compressor sales dept., and pump dept., Canadian Ingersoll-Rand Co. Ltd., Montreal.
References: R. E. Chadwick, E. Winslow-Spragge, R. DeL. French, C. M. McKergow, W. Taylor-Bailey.

CASSIDY—HERBERT, of Montreal, Que., Born at Saint John, N.B., Oct. 22nd, 1907; Educ., 1926-28, 2 year day course, steam and electl. power plant, Wentworth Institute, Boston. Cert. of Grad., 1928; 1929 (May-Dec.), dftsman., Riley Stoker Corpn., Worcester, Mass.; 1929-31, dftsman., Bethlehem Shipbldg. Corpn., Quincy, Mass.; 1932-36, designer-dftsman., J. Fred Williamson Ltd., Saint John, N.B.; 1936-37, Diesel instructor, Saint John Vocational School; at present, dftsman., Canadian Industries Limited, Montreal, Que.
References: W. J. Johnston, A. L. Harkness, F. T. Gnaedinger, F. N. Harling, W. T. Dempsey, R. M. Carmichael.

CORCORAN—JAMES DESMOND, of 523 Donlands Ave., Toronto, Ont., Born at West Hartlepool, England, Oct. 13th, 1900; 1916-21, ap'tice ship dftsman; 1917-18, mechanic, R.A.F.; 1924-25, dftsman., E. J. Fetherstonhaugh & Son., Toronto and Montreal; 1925-27, dftsman., Township of East York; 1927-28, chief dftsman. and 1928 to date, asst. engr., Township of East York.
References: G. R. Jack, W. Barber, J. S. Galletly, R. Harrison, A. E. Berry, G. W. Rayner.

COXON—GEORGE DOUGLAS, of 64 Bayswater Ave., Ottawa, Ont., Born at Ottawa, Sept. 14th, 1906; Educ., Ottawa Technical School. I.C.S. in Civil Engineering; 1923-26, waterproofer, Western Concrete Waterproofing Co., Detroit; 1927, Mich. Central Railroad Co.; 1927-28, Degrens Concrete Waterproofing Co., Detroit; 1929-37, engrg. and water dept., City of Ottawa. 1930-32, i/c of inspection of concrete and testing of materials during constrn., 1932-34, filter operator, 1935-36, pump operator, and 1936 to date, elect'l. mtce. operator, Ottawa Water Purification Plant, Ottawa, Ont.
References: W. E. MacDonald, F. C. Askwith, W. M. Johnstone, W. F. M. Bryce, G. F. Taylor.

DYKE—WILLIAM EDGAR, of 622 St. Joseph St., Lachine, Que., Born at Belleville, Ont., Sept. 11th, 1909; Educ., B.A.Sc., Univ. of Toronto, 1934; 1934-35, sampler, Sylvanite Gold Mines; 1935-36, instr'man. and dftsman., Dept. of Northern Development of Ontario; 1936-37, instr'man and dftsman., Dept. of Highways of Ontario; at present, estimator and designer, plate and boiler dept., Dominion Bridge Co. Ltd., Montreal.
References: A. S. Wall, R. S. Eadie, F. Newell, C. R. Young, R. E. Smythe.

HOLT—WILLIAM GEORGE HERBERT, of 19 Campbell Ave., Montreal West, Que., Born at Toronto, Ont., Dec. 29th, 1912; Educ., B.A.Sc., Univ. of Toronto, 1936; 1933-35 (summers), work with various tool companies in Toronto; July 1936 to date, mech'l. designer, Dominion Bridge Co. Ltd., Lachine, Que.
References: E. A. Allcut, R. W. Angus, F. Newell, R. H. Findlay, K. O. Whyte.

JOHNSON—JAMES HENRY, of Tillsonburg, Ont., Born at Waverly, N.Y., Feb. 26th, 1892; Educ., Mech. Engr., Syracuse Univ., 1915; 1917-19, Coast Artillery, civil engrg.; 1915-17, engrg. dept., The Merrell Soule Co., mfgrs. of milk products, etc., dfting., machine design, plant layout, suptg. constrn. and installn., and 1919-20, asst. chief engr. i/c dfting room for same company; 1920-29, chief engr., The Canadian Milk Products Ltd., Toronto. engrg. mtce., constrn. work, designing, and new equipment installn., etc. In 1929 The Borden Company Ltd. took over the C.M.P. Limited and added three major plants for direct supervision as above. 1934-36, special job of bldg. and equipping large milk plant, Phoenix, Arizona; 1936 to date, continuing as chief engr., Borden Company Limited, in Canada, also acting as consultant here as chairman of the Canadian Engineering Committee. Consltg. and assisting in various new constrn. jobs in New York State and Michigan. (R.P.E. State of New York.)
References: D. S. Scrymgeour, H. A. McKay, A. O. Wolff.

KEMSLEY—SYDNEY HYDE, of Devonshire, Bermuda, Born at Bloemfontein, Orange Free State, Union of South Africa, Sept. 30th, 1905; Educ., Senior Cambridge Local Cert, 1921. I.C.S. Private study; 1925-26, asst. to engr. i/c marsh reclamation, Public Works Dept., Bermuda; 1926, junior dftsman., Western Electric Co., New York City; 1926-27, dftsman and field work, Motyer Constrn. Co., Bermuda; 1927-28, junior engrg. asst., Public Works Dept., Bermuda; 1928-30, qualified asst. to J. H.

Dale, engr. and surveyor, Hamilton, Bermuda; also engr. to the Corpn. of Hamilton, and private practice; 1930 to date, surveyor, Public Works Dept., Bermuda. Responsible to Director of Public Works for land and engrg. surveys for public works and lands. i/c drawing office records and plans.
References: F. G. Rounthwaite, T. C. Main, C. G. DuCane, J. H. Trimingham, F. S. B. Heward.

LANG—EDWIN GEORGE POWER, of 2064 St. Catherine St. West, Montreal, Que., Born at Wimbledon, England, March 5th, 1896; Educ., Stanley Technical School and South Norwood Polytechnic, Croydon. I.C.S. Private tuition; 1913-16, timekpr., and rodman, Toronto, Ont.; 1916-20, Second Air Craftsman., R.A.F.; 1920-25, student, and asst. on theatre constrn. in England; 1925-26, dftsman., Shawinigan Engineering Co., Montreal; 1926-29, trackwork and field engr., Canadian Steel Foundries Ltd., Montreal, design assembly, and installn. of steam and electric trackwork. Railroad and topographical surveying. Testing materials. With the same company 1929-30, as field and efficiency engr., on installn. of machy., bldg. constrn., pipe laying, estimates, trackwork installn., general foundry supervision, and from 1930-33, cost engr., controlling engrg. and mtce. expenditures; 1933-36, misc. temporary positions; at present, inspecting and testing gravel deposits in Ontario, with Donald-Hunt Ltd., Inspection Engineers, Montreal, Que.
References: J. A. McCrory, C. R. Lindsey, W. McG. Gardner, L. McCoy, H. W. B. Swabey.

LOGGIE—GERALD PURVES, Lieut.-Col., R.C.O.C., of Ottawa, Ont., Born at Fredericton, N.B., Mar. 31st, 1884; Educ., Grad., R.M.C., 1905; 1905-12, Royal Canadian Artillery; 1912 to date, Royal Canadian Ordnance Corps—1912-21, District Ordnance Officer, M.D. No. 13, Calgary; 1921-29, District Ordnance Officer, M.D. No. 10, Winnipeg; 1929-36, Director of Equipment and Ordnance Services, National Defence Headquarters; 1936 (May-Dec.), Senior Ordnance Officer, Headquarters Depot, Ottawa; at present, Ordnance Representative, Dept. of National Defence, under High Commissioner for Canada.
References: G. J. Desharats, T. V. Anderson, E. W. Stedman, N. C. Sherman, G. R. Turner, G. Ogilvie.

MacNEIL—DUNCAN PAUL, of 29½ Commercial Street, Glace Bay, N.S., Born at Bridgeport, N.S., March 1st, 1910; Educ., B. Eng. (Mech.), N.S. Tech. Coll., 1936; 1926-28, constrn. work at coal mine operated by New England Fuel and Transportation Co., West Virginia; 1929-33 (summers), elect'l. dept., Dominion Coal Company, New Waterford, N.S.; 1934, instrument work for Highway Dept. of N.S.; 1936 (June-Dec.), making a lubrication study at all Dominion Coal Company Collieries; 1936-37, general test engr., Dominion Coal Company, Glace Bay, N.S., and at present, chief mechanic by night, at No. 10 Colliery, New Waterford, N.S.
References: W. S. Wilson, S. C. Mifflen, R. R. Murray, A. Ball, J. J. Sears.

MORGAN—RALPH TERRENCE, of Three Rivers, Que., Born at Montreal, Dec. 28th, 1912; Educ., B.Eng., McGill Univ., 1935; 1930 (summer), boiler installns., Babcock-Wilcox; 1934 (summer), Canadian Stebbins Engrg.; 1935 to date, mech'l. engr., Canadian International Paper Co. Ltd., Three Rivers, Que.
References: K. S. LeBaron, C. H. Champion, A. C. Abbott, E. Brown, C. M. McKergow.

PARTRIDGE—JOHN KENNETH, of 84 Blantyre Ave., Toronto, Ont., Born at Rawdon, Yorks., England, June 6th, 1888; Educ.,1906-09, Univ. of Leeds. Passed Assoc. Membership exams. of the Inst. Civil Engrs. (London), Oct. 1909; 1905-06, ap'tice, mech. workshops; 1909-11, ap'tice, city of Leeds municipal works; 1911-13, instr'man and dfting., C.P.R.; with the Dept. of Public Works of Canada as follows: 1913-14 and 1919-22, dftsman., 1922-31, junior engr., 1931-37, asst. engr., and at present, senior asst. engr.
References: K. M. Cameron, H. J. Lamb, E. Viens, W. E. Bonn, R. F. Legget.

SMITH—JOHN LESLIE, of 108 Russell Road, Overbrook, Nr. Ottawa, Ont., Born at Cawood, Yorks., England, May 31st, 1895; Educ., B.Sc., Univ. of Leeds, 1922; 1922-25, student at the Airedale Collieries, Ltd., Castleford, Yorks.; 1925-28, junior technical officer, Royal Aircraft Establishment, So. Farnborough, England; 1928-29, res. technical officer, at the Gloster Aircraft Co., Boulton & Paul Ltd., Bristol Aeroplane Co. Ltd., England; 1930-36, senior asst. engr., aeronautical engrg. divn., Dept. of National Defence, Ottawa, Ont.; Jan. 1937 to date, senior asst. engr., aeronautical engrg. divn., Dept of Transport, Ottawa, Ont.
References: E. W. Stedman, A. Ferrier, J. T. Dyment, A. T. Cowley, J. A. Wilson.

STEVENTON—HARRY ELGIN, of 75 Queen St. South, Hamilton, Ont., Born at Toronto, Ont., Sept. 30th, 1902; Educ., B.Sc. (E.E.), Univ. of Man., 1933; With the Otis-Fenson Elevator Company, Hamilton, Ont., as follows: 1922-28, constrn. and service work including complete installn. of major elevator installns. such as mech. and elect'l. layouts, supervision of men, and final adjustment to equipment; 1929-33, summer work similar to above; April 1935 to date, service engrg. work, such as analysing trouble experienced by mechanics in the field on all service work; studying and recommending changes to existing equipment to bring same to present day standards; design of special equipment for service work where standard equipment cannot be used.
References: W. J. W. Reid, E. V. Caton, E. P. Fetherstonhaugh, N. M. Hall, E. G. MacKay, W. D. Black, A. R. Hannaford.

TEAGLE—ROBERT WILLS, of Montebello, Que., Born at Toronto, June 21st, 1902; Educ., B.A.Sc., Univ. of Toronto, 1925; 1922-23-24 (summers), dfting work; With the Turner Constrn. Co. of New York, as follows: 1925, timekpr., Johnstown, Pa., and material clerk, Boston; 1925-26, asst. cost acct., Springfield, Mass.; 1926, cost acct., Long Island City; 1926-27, field engr., Brooklyn and Manhattan; 1927, expediter, Chicago; 1927-28, Teagle and Sons, Toronto, supt. of constrn., Toronto East End General Hospital; 1928, Dominion Appraisal Co., Toronto; 1928-30, George A. Fuller Co., Montreal, expediter and office asst., Dominion Square Bldg.; With the Seigniory Club as follows: 1930-32, expediter and estimator, and 1932 to date, asst. constrn. mgr. and asst. to the operating mgr.
References: J. L. E. Price, M. D. Stewart, H. L. Dowling, D. D. Whitson, L. H. Burpee, A. S. Rutherford, A. T. Bone, C. A. Norris.

VINET—PIERRE PAUL, of 5584 Canterbury St., Montreal, Que., Born at Montreal, Jan. 12th, 1907; Educ., B.A.Sc., Ecole Polytechnique, Montreal, 1928. Mech. Engr., Mass Inst. Tech., 1929; R.P.E. of Que.; 1926-27-28, summer work with E. Gohier, C.E., and the City of Verdun; 1929 (6 mos.), with the Rolland Paper Co.; 1930 (6 mos.), with Baulne & Leonard; Fuel and combustion engr., with the following: 1930-31, Anthracite Institute; 1931-33, Delaware L. & W. Coal Co.; 1933-35, Philadelphia and Reading Coal and Iron Co.; January 1932 to date, professor in heat engrg. at the Ecole Polytechnique, Montreal. Also consltg. engr., heating, plumbing, ventilation, electricity.
References: A. Duperron, A. Frigon, J. T. Lafreniere, O. O. Lefebvre, A. Mailhiot, J. A. Beauchemin, A. Cousineau, J. A. Lalonde.

WALKEY—ARTHUR WALLACE, of Winnipeg, Man., Born at Winnipeg, Apr. 10th, 1909; Educ., B.Sc. (Civil), Univ. of Man., 1931; 1927 (May-Dec.), estimator, Dominion Bridge Co. Ltd., Winnipeg; 1930 (June-Oct.), inspr constrn. of Churchill elevator; 1931-34 (intermittent), instr'man. and asst. on surveys, Natural Resources of Manitoba; 1934 (2 mos.), instr'man, on survey of mineral claims; 1935 (3 mos.), engr. i/c of assessment work on mineral claims; 1935 (3 mos.), inspr., Good Roads Board of Manitoba; 1935 (2 mos.), engr. i/c constrn. earth reservoir; 1936, engr. with Greater Winnipeg Sanitary District; 1936 (Apr.-Aug.), engr. i/c camp constrn., road bldg., and prospecting of mineral claims in B.C.; 1936-37, engr. and steel supt., constrn. of disposal plant, Winnipeg; June 1937 to date, junior engr., Dept. of Public Works Canada, Winnipeg, Man.
References: T. C. Main, D. M. Stephens, J. A. MacGillivray, A. E. Macdonald, F. G. Goodspeed.

WRIGHT—ERROL HARCOURT, of Edmonton, Alta., Born at Ste Helene de Kamouraska, Que., Nov. 13th, 1909; Educ., B.Sc., Queen's Univ., 1934; 1926-27, rodman and instr'man., Gatineau Power Company; 1927, rodman, 1927-28, topogr. and instr'man., C.P.R.; 1929 (5 mos.), instr'man., Canada Power and Paper Co.; with Shawinigan Engineering Company as follows: 1928-29, instr'man., 1930 (2½ mos.), asst. to res. engr. on constrn, Toro Rapids Storage Dam; 1931 (4½ mos.), asst. to res. engr, on constrn. of Rapide Blanc power development; 1934-35, instr'man. and dftsman. on constrn., Dept. of Highways of Ontario; 1935-36, asst. combustion engr., and 1936 to date, asst. engr., engrg. dept., Northwestern Utilities Limited, Edmonton, Alta.
References: J. Garrett, E. Nelson, A. W. Haddow, G. J. Smith, G. R. Rinfret.

## FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

WIGGS—GORDON LORNE, of 4797 Grosvenor Ave., Montreal, Que., Born at Quebec, Que., July 1st, 1898; Educ., B.Sc., McGill Univ., 1921; 1920, Shaw. Water and Power Co.; 1920-21, Canadian Crocker Wheeler Co.; 1921-22, Canadian Westinghouse Co.; 1922-28, with Mechanics Supply Co. Ltd., 1924-28 in charge of engrg. dept.; 1929-30, private practice as consltg. engr.; 1930-32, mgr., Montreal sales office, G. A. Dunham Co. Ltd., Toronto; 1933 to date, private practice as consultg. engr., specializing on elect'l. and mech'l. equipment of bldgs., and more particularly on air conditioning. (*St. 1916, A.M. 1927.*)
References E. A. Ryan, F. A. Combe, F. S. B. Heward, B. R. Perry, G. M. Pitts, C. V. Christie, C. K. McLeod, C. M. McKergow.

## FOR TRANSFER FROM THE CLASS OF JUNIOR

AITKENS—JOHN CURREY, of Red Lake, Ont., Born at Boissevain, Man., Oct. 11th, 1905; Educ., B.Sc. (C.E.), Univ. of Man., 1929. R.P.E. of Man.; Summers 1924-25-26, rodman and field dftsman., and Summer 1927, instr'man. and asst. chief of party, Dom. Topog'l. Surveys Br.; Summer 1928, instr'man., and 1929-31, office engr., City of Winnipeg Hydro-Electric System on constrn. of Slave Falls hydro-electric plant; 1933-35, inspecting engr., Dept. of National Defence Relief Project; 1935-36, office engr., Dom. Dept. of Agriculture, Water Development Committee; 1936-37, temporary assessor, City of Winnipeg; at present, mine engr., Madsen Red Lake Gold Mines Ltd., Red Lake, Ont. (*St. 1928, Jr. 1934.*)
References: J. N. Finlayson, G. H. Herriot, J. W. Sanger, J. A. MacGillivray, B. Russell, G. G. McEwen.

BARBOUR—CLARENCE ALLEN, of 55 Lazard Ave., Town of Mount Royal, Que., Born at Saint John, N.B., Feb. 14th, 1907; Educ., B.Sc. (E.E.), Univ. of N.B., 1931; 1929-30, summers, installer in switchboard and installn. depts., N.B. Telephone Co. Ltd., Saint John; 1931 (July-Oct.), Saint John Harbour Commn.; 1931-32, journeyman and electrn., with Canadian Comstock Co. and Sterling Electric Co.; 1933-37, proprietor, Maritime Radio and Electrical Supplies, Saint John, N.B., in charge of sales and service; June 1937 to date, commercial dept., Canadian Marconi Co., at present assembling and making transformers. (*St. 1930, Jr. 1935.*)
References: A. A. Turnbull, W. J. Johnston, A. Gray, J. F. Plow, J. R. Freeman, A. F. Baird.

CLARK—JAMES ERNEST, of 789 Carling Ave., Ottawa, Ont., Born at Pulborough, England, July 30th, 1904, Educ., B.Sc., Queen's Univ., 1928; 1926 (summer), mech. training, Can. Locomotive Works, Kingston; 1927 (summer), elect'l. training, and 1928-29, complete test course, Canadian General Electric Co.; 1929-37, field engr., Bell Telephone Company of Canada, and at present field engr. in transmission dept. (*St. 1928, Jr. 1932.*)
References: J. A. Loy, D. M. Jemmett, R. A. Low, J. E. Goodman L. F. Grant

HOULDEN—JAMES WALTER, of Brownsburg, Que., Born at Hamilton, Ont., Feb. 15th, 1904; Educ., B.Sc., Queen's Univ., 1927; 1927-28, ap'ticeship with the Ingersoll-Rand Co., and from 1929-35, with Canadian Ingersoll-Rand as follows: 1929-31, i/c of engrg. on pulp and paper mill equipment, Diesel engines and rock crushers; 1932-34, personal survey all paper mills, Winnipeg to Atlantic, to introduce new paper machy.; 1934-35, production engr. and asst. to supt.; 1935 to date, ballistic engr., Canadian Industries Limited, at present i/c ballistic laboratory. (*St. 1927, Jr. 1929.*)
References: L. M. Arkley, L. T. Rutledge, G. M. Dick, E. T. Harbert, S. R. Newton, C. H. Jackson, G. M. Sutherland.

KING—ERIC CHARLES, of Island Falls, Sask., Born at Llanisten, Nr. Cardiff, So. Wales, Feb. 2nd, 1908; Educ., Passed E.I.C. Exams. under Schedule "B" for admission as Junior in 1935. Passed E.I.C. Exams. for admission as Assoc. Member (Schedule "C"), in May 1937; 1924-25, ap'ticeship with Pontoon Ship Repairing Co.; 1927-30, power house operator, Canadian Utilities Ltd., Calgary; 1931-33, trans. and distribution mtce., Calgary Power Co.; with the Churchill River Power Co. Ltd., as follows: 1933-35, 3rd and 2nd power house operator, and from 1935 to date, relief first operator, in complete charge, during hours of shift, of the power house, all the apparatus therein, and of the transmission lines. To handle emergencies the first operator must have a thorough knowledge of the principles involved in making decisions affecting operation, including performance of generators, transformers, switchgear, and transmission lines under any abnormal conditions, etc. (*Jr. 1935.*)
References: J. B. D'Aeth, F. S. Small, E. W. Bowness, J. McMillan, H. B. Sherman.

LUSBY—GERALD WINKWORTH, of 1268 Hall Ave., Windsor, Ont., Born at Amherst, N.S., Aug. 21st, 1903; Educ., B.Sc. (Mech.), N.S. Tech. Coll., 1925; 1925-26, rodman on bldg. survey, Canadian International Paper Co., Three Rivers, Que.; 1926-27, assting with installn. and compilation of piping costs and records, Fraser Brace Engrg. Co., Gatineau, Que.; 1927 to date, layouts and design of plant equipment, Ford Motor Co. of Canada Ltd., Windsor, Ont. (*St. 1925, Jr. 1931.*)
References: J. E. Porter, C. G. Walton, V. W. MacIsaac, W. A. Dawson, B. Candlish, E. Chorolsky.

MATHIESON—THOMAS STANLEY, of Falconbridge, Ont., Born at Beachburg Ont., Sept. 29th, 1903; Educ., B.Sc., Queen's Univ., 1926; 1926-27, asst. to combustion engr., Canadian International Paper Co.; 1927-28, mech'l. dftsman., Canadian International Paper Co., and Abitibi Power and Paper Co.; 1928-29, mech'l. designer, American Cyanamid Co., Niagara Falls, Ont.; 1929-31, mech'l. and concrete designer, Alcoa Power Co. Ltd., Arvida, Que.; 1932-33, mech'l. designer, Siscoe Gold Mines Ltd.; 1934 to date, gen. industrial designer, Falconbridge Nickel Mines Ltd., Falconbridge, Ont. (*Jr. 1928.*)
References: E. W. Neelands, H. J. Kurtz, G. O. Vogan, J. A. Knight, R. M. Carmichael, L. M. Arkley, L. T. Rutledge.

MORTON—RALPH MacKENZIE, of 3455 Prudhomme Ave., Montreal, Que., Born at Barmouth, No. Wales, Feb. 24th, 1902; Educ., B.A.Sc., Univ. of B.C. R.P.E. of B.C.; 1918-20, mach. ap'tice; Summers 1922-23-24, instr'man., electr'n. helper, dftsman.; 1925-26, elec. test course, Can. Gen. Elec. Co., Peterborough, Ont.; 1926-29, junior switchgear engr. with same company; 1929-32, asst. to relay engr., B.C. Electric Railway Co., making short circuit studies and developing relay protection; 1932 to

1937, non-technical sales work, Morton Clarke Co.; at present elect'l. engr., Bepco Canada Ltd., Montreal, Que. (*St. 1923, Jr. 1929.*)
References: J. D. Chisholm, B. C. Hicks, R. A. Yapp, E. A. Wheatley, W. H. Powell.

NORMAN—DOUGLAS, of 300 South Kingsway, Toronto 3, Ont., Born at Toronto, July 21st, 1904; Educ., B.Sc. (E.E.), Univ. of Man., 1926; Summers 1923-24-25, chainman and rodman, C.N.R.; With Can. Gen. Elec. Co. Ltd., as follows; 1926-27, test dept., students' course; 1927-33, junior engr., transformer engrg. dept., and 1933 to date, distribution transformer engr., i/c design of distribution, constant current and misc. transformers. (*St. 1926, Jr. 1931.*)
References: C. E. Sisson, E. P. Fetherstonhaugh, W. M. Cruthers, L. DeW. Magie, W. E. Ross, H. M. Black, F. A. Becker.

ROBSON—RICHARD CHRISTOPHER, of Powell River, B.C., Born at Bromley, Kent, England, July 13th, 1904; Educ., 1923-25, Univ. of B.C. Graduate, Advanced course in elect'l. engrg., Govt. Schools, Vancouver; 1925-26, field survey, road location, grading, field notes, harbour soundings, for W. G. Swan, M.E.I.C., Vancouver; 1926-27, mech. and elec. dftsman., American Can Co., Vancouver; 1927-29, mech. and structl. dftsman., Canadian Fishing Co., Vancouver; 1929-31, designing dftsman. and engr., mech., structl. and electl. power and lighting layout design, Consolidated Mining and Smelting Co., Trail, B.C.; 1931-32, designing dftsman. and engr., hydro-electric power development, West Kootenay Power and Light Co. Ltd., Trail, B.C.; asst. to mech. supt. and plant engr., Canadian Fishing Co.; 1935-36, designing dftsman. and engr., structl. and elec. layout, B.C. Sugar Refining Co. Ltd., and at present, structl. engr. for same company on structl. design and general mtce., Power River, B.C. (*Jr. 1932.*)
References: E. A. Wheatley, W. G. Swan, H. P. Archibald, W. H. Powell, A. E. Wright, A. S. Mansbridge, A. C. Ridgers.

ROWE—GORDON WILLIAM, of 189 North Court St., Port Arthur, Ont., Born at Leeds, England, Jan. 20th, 1904; Educ., B.Sc. (Civil), Univ. of Man., 1927; 1927-28, res. engr., power plant constrn.; 1928, designing and detailing, power plant constrn.; 1928-30, designing and detailing, and 1930-31, res. engr., grain elevator constrn. for C. D. Howe & Co. Ltd., Port Arthur; 1931-33, asst. to city engr., Lethbridge; 1935-36, field engr., sewage disposal system, Winnipeg; 1936, dredging inspr., Montreal, for the Dept. of Transport; 1937 to date, field engr., reinforced concrete grain elevator constrn., C. D. Howe Co. Ltd., Port Arthur, Ont. (*St. 1926, Jr. 1931.*)
References: J. M. Fleming, B. A. Culpeper, S. E. Flook, J. T. Watson, J. Haimes.

## FOR TRANSFER FROM THE CLASS OF STUDENT

ANTENBRING—CLARENCE V., of 417 Machray Ave., Winnipeg, Man., Born at Winnipeg, Man., May 11th, 1903; Educ., B.Sc. (C.E.), Univ. of Man., 1926; 1925 (summer), instr'man. on constrn., Chicago, North Shore & Milwaukee R.R.; 1926 (summer), dfting., inspecting, designing on municipal engrg. works for town of Mundelin, also instr'man. on base line survey for Chicago subway system, for Kelker & DeLeew, Chicago; 1927 to date, designer of reinforced concrete structures for Cowin & Co. Ltd., Winnipeg, Man. (*St. 1934.*)
References: H. B. Henderson, E. S. Kent, A. E. Macdonald, G. H. Herriot, A. J. Taunton.

BACKLER—IRVING SAUL, of 1577 Van Horne Ave., Montreal, Que., Born at Manchester, England, Dec. 14th, 1907; Educ., B.Eng., McGill Univ., 1932. R.P.E. of Que.; Summers 1929-31, dftsman., Northern Elec. Co. Ltd., drilling machine, Noranda Mines, dftsman., Meagher Bros., Montreal, and asst. supt. on constrn. of apt. house, Montreal; 1932-33, designing engr., Allied Engineers, Montreal; 1933-35, designing engr., Backler & Gersovitz, Montreal; 1935 to date, consltg. engr., specializing in reinforced concrete and structl. steel design. (*St. 1930.*)
References: E. Kugel, E. Brown, R. DeL. French, J. Weir, G. J. Dodd.

BAILEY—LORING WITHALL, of Grand Falls, N.B., Born at Quebec, Que., July 30th, 1903; Educ., B.Sc. (E.E.), McGill Univ., 1925; 1923 (summer), operator, British American Nickel Corpn., Deschenes, Que.; 1925-27, students' course, and 1927, test foreman and dftsman., Canadian Westinghouse Co., Hamilton, Ont.; With the Gatineau Power Company as follows: 1927-28, res. engr. at St. Jerome, Que. i/c of constrn. of substation and installn. of equipment, also supervision of equipment installn. at Rawdon power house; 1928-34, designing engr. at Ottawa, and from Nov. 1934 to date, station supt., Grand Falls Station, and in charge of company property in New Brunswick. (*St. 1922.*)
References: W. G. C. Gliddon, G. G. Gale, W. E. Blue, A. V. Gale, R. F. Howard, J. Woodside, G. Stead, J. S. Parker.

BARBOUR—RONALD GRANVILLE, of Montreal, Que., Born at Saint John, N.B., Aug. 6th, 1903; Educ., B.Sc., 1924, M.Sc., 1927, Univ. of N.B.; 1924-26, engrg. course, Can. Gen. Elec. Co. Ltd., Peterborough and Toronto; with the Aluminum Co. of Canada Ltd., as follows: 1926-27, technical asst. on generating plant constrn., Arvida, Que.; 1927-28, asst. chief operator, generating plant; 1928-29, electl. engr. for constrn. and subsequent operation of electric slag ore reduction plant; 1929 to date, electl. engr., with McDougall & Friedman, Consltg. Engrs., Montreal, Que. (*St. 1924.*)
References: G. K. McDougall, E. A. Ryan, F. J. Friedman, M. S. Macgillivray, J. D. Fry, C. P. Creighton.

BARR—FREDERICK GORDON FORDYCE, of 43 Admiral Road, Toronto, Ont., Born at Toronto, Nov. 11th, 1904; Educ., B.A.Sc., Univ. of Toronto, 1927; With the Bell Telephone Company of Canada as follows: 1927-28, student engr., and 1928-30, asst. to toll line engr., gen. traffic dept.; 1931 to date, asst. to equipment engr. (western area), traffic engrg. of central office equipment, principally dial equipment. (*St. 1926.*)
References: T. R. Loudon, C. L. Brooks, D. G. Geiger, A. M. Reid, A. S. Poe.

BERRINGER—ORMUS BENJAMIN, of Lunenburg, N.S., Born at Lunenburg, Nov. 19th, 1907; Educ., B.Sc. (Mech.), 1932, B.Eng. (Civil), 1935, B.Eng. (Elec.), 1935, N.S. Tech. Coll.; 1930 (summer), asst. mech. inspr., Aluminum Co. of Canada; 1935 (summer), road inspr., Milton Hersey Co. Ltd.; 1935, constrn. supt., Standard Paving Co.; 1936 (May-Nov.) and 1937 (May-Oct.), plant inspr., Milton Hersey Co. Ltd.; at present paving inspr., Lunenburg, N.S. (*St. 1933.*)
References: S. Ball, M. F. Macnaughton, H. W. L. Doane, G. J. Currie.

BILLETTE—ROGER, of 549 Bonaventure St., Three Rivers, Que., Born at Valleyfield, Que., Dec. 23rd, 1909; Educ., B.Sc. (E.E.), McGill Univ., 1931. R.P.E. of Que.; Summers 1928-29, surveying and dfting.; 1931 (3 mos.), sheet steel and ornamental iron salesman; 1932 (Jan.-Apr.), heating layouts, Gurney Massey Co.; 1932 (Apr.-Oct.), electl. constrn., Beauharnois Constrn. Co.; 1933, gen. dfting., City of Valleyfield; with the Shawinigan Water & Power Company as follows: 1933-36, junior distribution engr., 1936 (Feb.-June), meter shop asst., and June 1936, to date, designer and tester, electl. repair dept. (*St. 1931.*)
References: R. H. Mather, A. C. Abbott, C. R. Reid, A. S. Runciman, J. H. Fregeau, L. McGillis.

BOUTILIER—FREDERICK THOMAS, of Arvida, Que., Born at Sydney, N.S., April 5th, 1904; Educ., B.Sc. (Mech.), 1928; 1928 (June-Nov.), asst. to steam engr., Dom. Steel and Coal Corpn., Sydney, N.S., and Nov. 1928 to Dec. 1929, dfting and designing for same company; 1930-31, technical asst., mechl. dept., Aluminum Co. of Canada, Arvida, and with same company to date as follows: 1931-32, technical asst. in aluminum plant; 1932-35, gen. foreman, remelting and alloy dept., and Sept. 1935 to date, asst. to Aluminum Plant Supt. (*St. 1928.*)
References: A. P. Theuerkauf, W. S. Wilson, H. R. Wake, A. W. Whitaker, Jr., M. G. Saunders, A. C. Johnston, R. H. Rimmer.

BRADDELL—EBERHARD SYLVESTER, of 1441 Drummond St., Montreal, Que., Born at East Bay, Man., Dec. 16th, 1910; Educ., B.Sc. (E.E.), Univ. of Man., 1932; 1929 (summer), gen. mech., C.P.R., Sask. and Alta.; 1930 (summer), asst. steel inspr., also i/c production of galvanizing dept., Manitoba Bridge and Iron Works Ltd.; with the Winnipeg Electric Company as follows: 1931 (summer), engrg. asst. on (underground) electrolysis survey; 1932-34, engrg. asst. on electrolysis survey, investigation and research; 1934-36, asst. in distribution engr.'s dept., voltage testing and inspection on constrn.; 1937 (Mar.-Apr.), dftsman. in engrg. dept.; 1936 (Jan.-Oct.), asst. in apparatus sales dept., English Electric Co. of Canada Ltd., commercial phases of manufacture of power apparatus; at present, power apparatus sales engr., Northern Electric Co. Ltd., Montreal, Que. (*St. 1931.*)
References: E. V. Caton, E. P. Fetherstonhaugh, J. N. Finlayson, T. C. Main, W. R. Bunting.

BRITTAIN—NORMAN WESTAWAY, of Minto, N.B., Born at Welsford, N.B., June 4th, 1905; Educ., B.Sc. (C.E.), Univ. of N.B., 1932. R.P.E. of N.B.; 1925-28, dftsman., appraising, switchboard installn. and line constrn., N.B. Telephone Co. Ltd., Saint John, N.B.; 1929 (summer), Provisional Pilot Officer, R.C.A.F., Camp Borden; 1930 (summer), instr'man. i/c surveys, Lake George Mines Ltd.; 1931 (summer), engr. i/c surveys for Miramichi Lumber Co. Ltd., in coal mines at Minto, N.B.; 1932 to date, private practice in civil engrg., mining, surveying, railroad constrn. etc. (*St. 1932.*)
References: J. Stephens, E. O. Turner, A. A. Turnbull.

BURRI—HENRY WILLIAM, of Port Hope, Ont., Born at New York, March 4th, 1909; Educ., B.Eng. (Mech,), McGill Univ., 1935; 1926 (6 mos.), installer, Bell Telephone Co. of Canada; 1926-28, telephone circuit dftsman., also checker, Northern Electric Co. Ltd.; 1928-30, mech. dftsman., Crane Limited; 1935-37, with Warden King Ltd. (subsidiary of Crane Ltd.), i/c plant drawing office, designing new machy., conveying systems, product, layouts, etc.; at present, with Mathews Conveyer Co. Ltd., Port Hope, Ont., proposition mech'l. engr., designing and drawing up proposed conveying systems to data, etc. (*St. 1934.*)
References: E. Brown, C. M. McKergow, L. R. McCurdy, A. R. Roberts, J. F. Plow.

CAMPLONG—LLOYD W., of Shawinigan Falls, Que., Born at Hudson, Que., Feb. 13th, 1906; Educ., 1925-27, McGill Univ., completed first year engrg.; 1927-28, layout engr., A. F. Byers & Co.; 1928-29, asst. field engr., Bell Telephone Co. of Canada; with Fraser Brace Engrg. Co. Ltd., as follows: 1925, reinforced steel checker; 1926, special cost clerk; 1927, asst. to constrn. engr.; 1929-30, quantity engr., and at present, quantity engr. at Shawinigan Falls, Que. (*St. 1930.*)
References: W. M. Mitchell, P. C. Kirkpatrick, A. F. Byers, J. A. Loy, W. J. S. Dormer, G. R. Stephen.

CAPELLE—WILLIAM ABRAM, of 418 Broadway Court, Winnipeg, Man., Born at Winnipeg, Dec. 8th, 1910; Educ., B.Sc. (C.E.), Univ. of Man., 1932; 1926-31 (summers), chainman, rodman and instr'man., C.N.R.; 1935-37, design and layout of store alterations, T. Eaton Co. Ltd., Winnipeg, and at present, purchasing agent, engrs. dept., of same company. (*St. 1929.*)
References: H. A. Dixon, J. H. Edgar, E. P. Fetherstonhaugh, J. N. Finlayson, J. L. Charles, A. E. Macdonald, N. M. Hall.

CARSON—MERVYN SHANNON, of 204 Wineva Ave., Toronto, Ont., Born at Landis, Sask., June 29th, 1909; Educ., B.Sc. (Civil), Univ. of Sask. 1930; 1929-30 (summers), estimating and dfting. on paving projects, instr'man. on sewer and water constrn. work, town planning, dfting and surveys; 1930-31, design of storm sewerage system, and field engr., City of Saskatoon; 1931-33, field engr., i/c prelim. survey, layout, etc., on a reinforced concrete bridge over the Saskatchewan River; Dec. 1935 to date, production engr.. Link-Belt Ltd., Toronto, Ont. (*St. 1931.*)
References: C. J. Mackenzie, R. A. Spencer, R. E. Smythe, A. R. Greig, I. M. Fraser.

CARTER—JOHN RUSSELL, of Asbestos, Que., Born at Kagawong, Ont., Sept. 17th, 1904; Educ., B.A.Sc., Univ. of Toronto, 1931; 1925-26, carpentering, installing machy. and machine tender in pulp mill; 1927-28-29 (summers), lumber mill work, instr'man., Welland Ship Canal, res. engr., highway constrn.; 1930-33, with H.E.P.C. of Ontario, on steel and reinforced concrete design on generating stations at Alexander, Chats Falls; transmission stations at Leaside, Woodstock and Guelph; 1935-36, Dept. of Northern Development of Ontario, res. engr. on highway constrn., location, dfting, estimating quantities, setting grades and general supervision; 1936 (June-Dec.), development and prospecting with mining companies in Northern Ontario; April 1937 to date, designer, engrg. dept., Canadian Johns-Manville Co. Ltd., Asbestos, Que. (*St. 1931.*)
References: E. B. Dustan, R. C. McMordie, H. R. Cleveland, C. R. Young, R. E. Smythe.

CLARKE—OWEN MAWBEY, of Ewarton, Jamaica, B.W.I., Born at Westmoreland, Jamaica, June 8th, 1908; Educ., B.Sc., McGill Univ., 1931; 1928 (summer), asst. chemist, La Salle Montreal Coke Company; 1930 (summer), dftsman., Anglo-Canadian Pulp and Paper Mills, Quebec; 1931-32, inspr. of sub-assembly, Victor Radio of Canada; 1932-34, engr., and 1934-37, chief engr. and chief chemist, Worthey Park Sugar Factory, Ewarton, and at present, asst. manager, Worthey Park Estate. (*St. 1929.*)
References: C. M. McKergow, J. O'Halloran, H. W. Lea, E. Brown, L. R. McCurdy.

CLARKE—STEPHEN HERBERT, of Montreal, Que., Born at Hinckley, Leicester, England, Oct. 6th, 1903; Educ., 1920-24, Faraday House Electrical Engrg. College. Diploma, 1924; 2 years ap'ticeship with elect'l. mfg. companies under supervision of Faraday House; 1924-25, dfting office ap'tice, 1925-26, junior dftsman., W. H. Allen Sons and Co., Bedford, England; 1926-27, junior dftsman., Electric Constrn. Co., Wolverhampton; 1927-28, dftsman., Can. Gen. Elec. Co. Ltd., Peterborough, Ont.; 1929-31, elect'l. layout and dfting., Power Corporation of Canada, Montreal; 1931-32, with F. B. Brown, M.E.I.C., consltg. engr., i/c design and installn. for street lighting system for Town of Mount Royal; 1936 to date, i/c layout and constrn. of electrical plants for gold mines in Northern Quebec; at present, elect'l. engr., for Sladen Malartic Mines Ltd. (*St. 1933.*)
References: S. S. Colle, G. Kearney, H. S. Grove, J. H. McLaren, J. T. Farmer.

COOPER—LAWRENCE O'TOOLE, of 95 John St., Sudbury, Ont., Born at New Liskeard, Ont., Jan. 14th, 1909; Educ., B.Sc., 1930, M.Sc., 1931, McGill Univ., 1925-27, (summers), surveying, McIntyre Mine; 1928-30 (summers), R.C.A.F. Training course; 1931-34, lecturer, McGill Univ.; 1934 (summer), i/c triangulation party, 1934 to Aug. 1937, mine mechl. dept., and at present, asst. to master mechanic of mines, International Nickel Company, Sudbury, Ont. (*St. 1928.*)
References:—E. Brown, F. M. Wood, C. M. McKergow.

CRAIG—CARLETON, of Montreal, Que., Born at Ottawa, Ont., April 25th, 1909; Educ., B.Eng., 1933, M.Eng., 1934, McGill Univ.; Summers—1926-29, rodman, C.N.R., 1930, inspr., C.N.R., 1931, clerk, Bureau of Economics, C.N.R., 1937, instr'man. and inspr., C.N.R.; 1934 to date, lecturer, dept. of civil engrg. and applied mechanics and dept. of mathematics, McGill University, Montreal, Que. (*St. 1931.*)
References: E. Brown, R. E. Jamieson, W. Walker, G. J. Dodd, F. M. Wood

DALTON—PETER DUDLEY, of Toronto, Ont., Born at Hampstead, England, May 8th, 1906; Educ., B.Sc., McGill Univ., 1928; 1924-28 (summers), lineman and asst. wireman, C.P.R.; 1928-30, constrn. work, George A. Fuller Co. of Canada Ltd.; 1930 (May-Dec.), asst. plant engr., Canadian Kodak Co.; with George A. Fuller Co. of Canada Ltd., as follows: engr., estimator, job supt., 1930-35, asst. constrn. mgr., 1935-37, and at present, constrn. manager. (*St. 1926.*)
References: W. J. Armstrong, H. A. Babcock, K. B. Rybka, J. L. E. Price, C. S. L. Hertzberg, A. H. Harkness.

DARLING—THOMAS CREIGHTON, of 554 Grosvenor Ave., Westmount, Que., Born at Montreal, Sept. 13th, 1905; Educ., B.Sc., McGill Univ., 1927; 1927-28, test course, Gen. Electric Company, Schenectady, N.Y.; 1929 to date, sales engr., apparatus sales dept., Can. Gen. Elec. Co. Ltd., Montreal office. (*St. 1925.*)
References: F. P. Shearwood, F. W. Taylor-Bailey, A. B. Gates, H. R. Sills, B. Ottewell, K. O. Whyte.

DEANS—CHARLES WARBRICK, of 3049 West 27th St., Vancouver, B.C., Born at Summerland, B.C., June 14th, 1908; Educ., B.A.Sc., Univ. of B.C., 1930; M.Sc. (Structl.), Iowa State College, 1933; 1927-28-29 (summers), rodman, instr'man. and survey asst.; 1930-31, structl. steel dftsman., Western Bridge Co.; 1931-33, graduate and research asst., Iowa State College; with Western Bridge Company to date as follows: 1935-36, estimating quantities, designing structl. steel, 1936-37, estimator of quantities, and shop costs in structl. steel and machine shop work. (*St. 1928.*)
References: J. P. Mackenzie, E. C. Luke, E. A. Wheatley, H. N. Macpherson, A. Peebles.

DENTON—ALLAN LESLIE, of Bourlamaque, Que., Born at Scotchtown, N.B., Oct. 12th, 1904; Educ., B.Sc. (E.E.), Univ. of N.B., 1932; Summers 1930-31, elect'l. dept., Atlantic Sugar Refineries, and checker on tower line in N.B.; 1936 to date, office engr., Lamaque Mining Company, Bourlamaque, Que. (*St. 1932.*)
References: J. Stephens, E. O. Turner, S. R. Weston, M. W. Black, H. Mugaas.

DILL—EDWIN WILLSON, of Niagara Falls, Ont., Born at Toronto, Ont., Sept. 21st, 1905; Educ., B.A.Sc., Univ. of Toronto, 1928; 1928-30, dftsman., Gatineau Power Company; 1930-32, i/c of scheduling of excavating and dyking equipment over a 30 mile canal, Beauharnois Construction Co., Beauharnois, Que.; 1934-37, designer of equipment, and constrnal works, supervisor of constrn. and mtce., British American Oil Co., Toronto, Ont.; at present, designing dftsman., Carborundum Company, Niagara Falls, N.Y. (*St. 1929.*)
References:—W. E. Blue, M. V. Sauer, J. A. Knight, L. H. Burpee, C. H. Mitchell.

DUNLOP—JAMES RUSSELL, of 184 Primrose Ave., Ottawa, Ont., Born at Ottawa, Dec. 13th, 1907; Eudc., B.Eng., McGill Univ., 1935; at present, dftsman., Canadian International Paper Company, Ottawa, Ont. (*St. 1935.*)
References: G. Stephenson, A. N. Ball, K. F. Wrangell.

DYER—JOHN HENRY, of 10 Catherine St., St. Catharines, Ont., Born at Halifax, N.S., Dec. 7th, 1906; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1928; 1928 (summer), asst. installn. engr., Foundation Co. of Canada; 1928-30, student ap'tice, and 1930-33, junior engr., Canadian Westinghouse Co.; 1933-34, testing lab., Imperial Oil Refineries; 1935 (4 mos.), asphalt testing, Milton Hersey Co. Ltd.; 1936 (4 mos.), road inspr. for same company; 1935-37, asst. professor of engrg. St. Mary's College, Halifax, N.S.; at present, elect'l. switchgear diftsman., English Electric Co. of Canada, St. Catharines, Ont. (*St. 1928.*)
References: J. R. Dunbar, R. L. Dunsmore, J. R. Kaye, P. A. Lovett, S. Hairsine.

ECKENFELDER—GEORGE VICTOR, of Seebe, Alta., Born at Trochu, Alta., May 22nd, 1910; Educ., B.Sc. (C.E.), Univ. of Alta., 1933; 1927-31 (summers), chainman, rodman, C.N.R.; 1933 (5 mos.), coxswain, Candn. Hydrographic Service; 1934-35, asst. engr., and 1935-36, engr. in charge, Dept. of National Defence Relief Projects; at present, ap'tice engr., Calgary Power Company, Seebe, Alta. (*St. 1932.*)
References: H. J. McLean, G. H. Thompson, A. L. H. Somerville, A. G. Willson, J. McMillan, R. S. L. Wilson, H. R. Webb.

FLEURY—MAURICE, of 3989 Lacombe Ave., Montreal, Que., Born at Montreal, April 19th, 1907; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1934. R.P.E. of Quebec; 1930-31-32 (summers), field and office work, Collet Freres Ltd.; 1934 (June-Sept.), engrg. work, R. Duquette, C.E., Montreal; 1934-35, sales work, Industrial Scientific App. Co.; Nov. 1935 to date, asst. engr., Sun Trust Limited, Administrators, Montreal, Que. (*St. 1934.*)
References: A. Frigon, A. Duperron, T. J. Lafreniere, A. Mailhiot, A. Cousineau.

FONG—WILLIAM HINN, of 123 Dorchester St. W., Montreal, Que., Born at Canton, China, Nov. 6th, 1904; Educ., B.Sc. (E.E.), McGill Univ., 1928; 1925 (summer), expropriation work, Montreal Electr'l. Commission; 1926-27 (summers), power house constrn. and transmission line inspection, 1928-29, elct'l. substation constrn., and 1929-31, elect'l. foreman of constrn., Shawinigan Engineering Company; 1931 to date, relay mtce., Montreal Light Heat & Power Cons., Montreal, Que. (*St. 1926.*)
References: C. V. Christie, H. Milliken, L. H. Marrotte, A. B. Rogers, S. C. Hill.

FRASER—ALLAN DONALD WILLIAM, of Duparquet, Que., Born at Montreal, July 12th, 1910; Educ., B.Eng., McGill Univ., 1934; Summers, 1929-30, asst. on surveys, Bell Telephone Company of Canada; 1931, labourer, Dollard Constrn. Co.; 1933, dftsman. on surveys, Quebec Streams Commn.; 1934-37, asst. engr., and engr., Siscoe Gold Mines, Siscoe, Que.; at present, asst. in operating dept., Beattie Gold Mines, Duparquet, Que. (*St. 1934.*)
References: W. J. S. Dormer, J. E. Sproule, E. Brown, C. V. Christie, O. O. Lefebvre.

FRISKEN—ORVAL JAMES, of Peterborough, Ont., Born at Napanee, Ont., July 29th, 1907; Educ., B.Sc., Queen's Univ., 1929; 1928 (summer), survey and inspn. on bldg. constrn., Canadian Salt Co., Sandwich, Ont.; 1929-30, heating and ventilation, dfting and engrg., Trane Co. Ltd., Toronto; 1930 (summer), boilers, dfting., and 1930-32, asst. proposition engr., on power plant design for proposed work, heat transfer and combustion calculations and pricing, Babcock-Wilcox and Goldie-McCulloch, Galt, Ont.; May 1936 to date, asst. engr., De Laval Co. Ltd., Peterborough, design of dairy plant machy. and equipment. (*St. 1928.*)
References: R. L. Dobbin, L. M. Arkley, W. T. Fanjoy, A. B. Gates, H. R. Sills.

GAGNON—ELMORE GERARD, of 1045 Mount Royal Blvd., Montreal, Que., Born at Montreal, April 9th, 1908; Educ., B.Sc., McGill Univ., 1928; 1925 (6 mos.), power house constrn., Shaw. Water & Power Co.; 1926 (6 mos.), inventory of North Shore Power Co., and Three Rivers Traction for C. V. Christie, M.E.I.C.; 1928 to date, with the Northern Electric Co. Ltd., Montreal. Was first given a student's training course, and, on completion, detailed to work on telephone equipment (manual, tone and dial) in connection with authorizations, billings and quotations. At present, equipment service superintendent. (*St. 1925.*)
References: W. C. M. Cropper, J. S. Cameron, H. J. Vennes, W. V. Cheshire, E. S. Kelsey.

GOODMAN—HYMAN BERNARD, of 5653 Hutchison St., Montreal, Que., Born at Montreal, July 7th, 1909; Educ., 1926-31, McGill Univ. (2 subjects to complete in final year); 1928-29 (summers), dftsman and levelman; 1931-32, assembly line supervisor, R.C.A. Victor; 1937 (Apr.-July), instr'man., St. Lawrence Alloys, Beauharnois, Que.; July 1937 to date, inspection—field concrete control and instr'man., Donald-Hunt Ltd., at Black River. (*St. 1928.*)
References: P. H. Morgan, J. B. McRae, H. W. B. Swabey, C. M. McKergow, A. R. Roberts.

GROLEAU—ARNOLD JOHN, of Montreal, Que., Born at Cardinal, Ont., Feb. 25th, 1908; Educ., B.Sc. (E.E.), McGill Univ., 1928; 1926-27 (summers), dftsman. and sales engr., Northern Electric Co. Ltd., Montreal; with the Bell Telephone Co. of Canada as follows: 1928-33, engr. on staff of bldg. and equipment engr., 1933 to date, traffic dept., including the engrg. and operation of dial, manual and toll offices, and the development of methods and practices concerning dial operation. (*St. 1928.*)
References: R. V. Macaulay, C. L. Brooks, C. L. Dewar, H. E. McCrudden, C. V. Christie, E. Brown, G. A. Wallace.

HAMILTON—PARKER CLEVELAND, of 242 Oxford St., Halifax, N.S., Born at Upper Stewiacke, N.S., June 14th, 1908; Educ., B.Sc. (Civil), 1932, B.Sc. (Elec.), 1933, N.S. Tech. Coll.; Summers—student asst., Geol. Survey of Canada; 1930, asst. in dfting office, Halifax Harbour Commn.; 1933-34, mechanic, N.S. Technical College; 1935 (June-Nov.), road inspr., Milton Hersey Co. Ltd.; 1936 (Apr.-Dec.), asst. engr., Avon River Power Co., Halifax; May 1937 to date, district engr. for Gunite and Waterproofing Ltd. and Construction Equipment Co., Halifax, N.S. (*St. 1932.*)
References: J. B. Hayes, W. P. Copp, S. Ball, G. J. Currie.

HARTNEY—JAMES ROWAN, of Montreal, Que., Born at Weyburn, Sask., May 5th, 1908; Educ., B.Sc. (Mech.), McGill Univ., 1930; 1925-26 (9 mos.), machinist ap'tice, C.P.R. shops, Regina; 1927 (summer), on constrn. work, Hudson's Bay Rly.; 1928-29, road surveying, and with City of Regina Parks Dept.; 1930-36, inspr. with Canadian Fire Underwriters Association, sprinklered risk dept., Montreal; 1936 to date, in charge of inspection work for Willis, Faber & Co. of Canada Ltd., Insurance Brokers, Montreal. (*St. 1930.*)
References: C. M. McKergow, E. Brown, R. S. Lea, H. W. Lea, A. J. Foy, E. R. Smallhorn.

HAWLEY—ERIC FARWELL, of 27 Queenston St., St. Catharines, Ont., Born at Cowansville, Que., Apr. 20th, 1906; Educ., B.Sc. (E.E.), McGill Univ., 1931. R.P.E. of Que.; 1928-30 (summers), electrn. on power house constrn., Shawinigan Engineering Company; 1931-32, test course, Can. Gen. Elec. Co. Ltd., Toronto and Peterborough; 1933-34, electl. engr. on constrn. of Honore Mercier Bridge, Montreal; 1934-35, mtce. engr., Amos Divn., City Gas and Electric Corpn. Ltd., Montreal; 1935-36, elect'l. engr. for the corpn. of the Town of Amos, Que. (design, etc.); 1937 to date, asst. foreman, test dept., English Electric Co. of Canada Ltd., St. Catharines, Ont. (*St. 1930.*)
References: C. V. Christie, O. O. Lefebvre, H. K. Wyman, L. R. McCurdy, R. DeL. French, J. A. McCrory, J. A. Beauchemin, L. DeW. Magie, A. H. Munro.

HAYES—ELBERT HARVEY, of 4906 Queen Mary Road, Montreal, Que., Born at New Shoreham, R.I., Oct. 2nd, 1907; Educ., B.Sc. (E.E.), Univ. of N.B., 1928; Summers—1925, trans. line survey; 1926-27, dftsman. and elec. engr., Moncton Electricity and Gas Co.; 1934-35, dftsman., Bepco Canada Ltd.; with the Northern Electric Co. Ltd., Montreal, as follows: 1928-32, standardization engr., telephone circuits and equipment layouts, and 1935 to date, equipment engr., standardization of circuits and equipment layouts, estimates and specifications for telephone equipment. (*St. 1927.*)
References: A. F. Baird, H. H. Bell, W. C. M. Cropper, F. F. Fulton, E. O. Turner.

HOUGHTON—THOMAS WALTER, of Windsor Mills, Que., Born at London, Ont., July 30th, 1910; Educ., B.Eng., McGill Univ., 1932; 1929-30 (10 mos.), dftsman., Northern Electric Co.; 1931 (4½ mos.), concrete testing lab., Beauharnois Construction Co.; 1932-35, paper testing, machine shop, dftsman., Howard Smith Paper Mill, Beauharnois; 1936 to date, dftsman., Canada Paper Co., Windsor Mills, Que. (*St. 1931.*)
References: W. G. Scott, H. L. Johnston, J. C. Day, E. Brown, C. M. McKergow, D. de C. Ross-Ross, J. J. Crawford.

HULME—GORDON D., of 3411 Grey Ave., Montreal, Que., Born at Westmount, Que., Aug. 31st, 1908; Educ., B.Sc. (E.E.), McGill Univ., 1931; 1931-34, student ap'tice course, 1934-37, asst. engr., transmission line dept., and at present, engr., Dept. of Development, Shawinigan Water & Power Co., Montreal, Que. (*St. 1928.*)
References: J. A. McCrory, J. Morse, R. E. Heartz, J. B. Challies, F. S. Keith, N. A. Eager, G. R. Hale.

INGHAM—JASON HAROLD, of 4034 Dorchester St. W., Montreal, Que., Born at Bury, Lancs., England, March 19th, 1904; Educ., B.Eng., McGill Univ., 1935; 1923-24, Dominion Engrg. Works; 1924-26, Chas. Walmsley & Co. Ltd.; 1927-29, Dominion Bridge Co. Ltd.; 1930-31 (summers), Beauharnois Constrn. Co.; May 1935 to date, mech'l. designer, Dominion Bridge Co. Ltd., Montreal. (*St. 1933.*)
References: F. Newell, R. S. Eadie, R. H. Findlay, C. M. McKergow, A. R. Roberts, L. H. Burpee.

INGLES—CHARLES LEYCESTER, Lieut., R.C.E., of Chatham, Kent, England, Born at Thorold, Ont., June 24th, 1910; Educ., Grad., R.M.C., 1933. B.Sc. (Civil), Queen's Univ., 1934; 1934-35, Works Officer, M.D. No. 3, Kingston, Ont.; 1935-37, Works officer, M.D. No. 13, Calgary; at present taking course at the School of Military Engineering, Chatham, England. (*St. 1932.*)
References: E. J. C. Schmidlin, J. E. Lyon, L. F. Grant, H. H. Lawson, W. L. Malcolm, W. P. Wilgar.

JACKSON—KENNETH ARTHUR, of Edmonton, Alta., Born at Pincher Creek, Alta., Mar. 27th, 1910; Educ., B.Sc. (E.E.), 1932, M.Sc., 1934, Univ. of Alta.; 1935 to date, radio repairs and constrn. Taylor & Pearson Ltd., Edmonton, Alta. (*St. 1932.*)
References: H. J. MacLeod, W. E. Cornish, C. A. Robb, E. Stansfield, R. S. L. Wilson.

JONES—ALLISON MAURICE S., of Mauriceville, Que., Born at Boundary Creek, N.B., Nov. 29th, 1907; Educ., B.Sc. (Forestry), 1930, B.Sc. (Civil), 1934, Univ. of N.B.; 1927-33 (summers), cruiser, International Paper Co., instr'man., Canada Power and Paper Corpn., Dominion Forest Service; 1934-36, field engr. i/c all operating and constrn. work on a 50,000 cord operation, and 1937 to date, chief field engr., i/c design and location all bridges, roads, dams, etc., in connection with 230,000 cord pulpwood operation, Anglo-Canadian Pulp and Paper Mills Ltd. (*St. 1934*), (R.P.E. of Que.)
References: J. Stephens, E. O. Turner, A. F. Baird.

KAUTH—CARL GLADSTONE, of 69 Spadina Road, Toronto, Ont., Born at Napierville, Ill., Aug. 19th, 1909; 1927-3- (summers), various jobs, Ryan Constrn. Co., P-K Mills, Listowel, and Dufferin Paving and Crushed Stone Co. Ltd., Toronto; 1934 (summer), surveying, Dept. Lands and Forests Ontario; 1935-36, Lindetector inspr., and 1936 to date, operator, Dominion Oxygen Co. Ltd., Toronto (*St. 1934.*)
References: O. Holden, R. E. Smythe, L. T. Rutledge, R. A. Low.

KENT—WILLIAM LESLIE, of 1618 Pendrill St., Vancouver, B.C., Born at Content, Alta., Oct. 19th, 1907; Educ., B.Sc. (C.E.), Univ. of Alta., 1931; 1929-30 (summers), D.L.S., and transitman, C.P.R.; 1932 (Feb.-Apr.), designing dftsman. on bridge design for city engr., Edmonton; 1931-34, asst. to district surveyor and engr., Dept. Public Works, Alberta; 1935 (July-Oct.), inspn. engr. on constrn. of flume for Hixon Creek (Cariboo) Gold Mines Ltd.; at present, junior asst. engr., designing, estimating, etc., for Stuart Cameron & Co. Ltd., Vancouver, B.C. (*St. 1929.*)
References: J. W. Roland, R. S. L. Wilson, H. R. Webb, H. J. MacLeod, W. G. Swan, R. J. Gibb.

KIRK—WILLIAM DOUGLAS, of 4982 Queen Mary Road, Montreal, Que., Born at Douglas, Ont., Feb. 17th, 1903; Educ., B.Sc., Queen's Univ., 1928, M.Eng., McGill Univ., 1936. R.P.E. of Que.; 1927 (Apr.-Sept.), struct'l. dftsman., Canadian Vickers Ltd.; 1928-29, struct'l. dftsman., Canadian Bridge Co., Walkerville, Ont.; 1929-32, bridge dept., designing bridges and bldgs., C.P.R., Montreal; 1933-34, engr. on constrn. of Honore Mercier Bridge, Montreal; 1934-35, struct'l. designer, Vibra-Lite Ltd., Montreal; 1935 (Feb.-July), res. engr., postal terminal foundations, Anglin-Norcross Quebec Ltd.; Aug. 1935 to date, res. engr. on reconstrn. of Sutherland Pier, Montreal Harbour, for E. G. M. Cape and Co., Montreal. (*St. 1927.*)
References: J. B. Stirling, D. G. Anglin, O. O. Lefebvre, J. A. Beauchemin, P. B. Motley, A. R. Ketterson, R. E. Jamieson, D. S. Ellis.

LAZORKA—DICK, of Borden, Sask., Born at Borden, Sask., Aug. 4th, 1909; Educ., B.Sc. (Civil), Univ. of Sask., 1932; 1930 (summer), city engr.'s dept., Saskatoon; July 1935, foreman, sewer constrn., Dundurn Camp; 1935 (Aug.-Dec.), instr'man., Waskesin Townsite; 1936 (May-Nov.), development, Prince Albert National Park; May 1937 to date, timekpr., compiling reports on work under engrg. and constrn. service, Dept. of Mines and Resources, Prince Albert National Park. (*St. 1931.*)
References: C. J. Mackenzie, W. E. Lovell, R. A. Spencer, E. K. Phillips, G. M. Williams.

LEMIEUX—GILBERT, of 112 Abraham Hill, Quebec, Que., Born at Bienville, Que., June 7th, 1910; Educ., B.A.Sc., Ecole Polytechnique, Montreal, 1936. R.P.E. of Que.; 1936 (June-Aug.), surveying in Lake St. John District, Dept. of Highways of Quebec; 1936-37, engr., Lake St. John, Chibougamou Road; 1937 (Mar.-Apr.), surveying in Lake St. John District; April 1937 to date, engr., Senneterre-Mont Laurier Highway, Dept. of Highways of Quebec. (*St. 1935.*)
References: A. O. Dufresne, J. H. A. Laplante, A. Mailhiot, A. Frigon, A. Paradis.

LEVIN—MAX, of 1847 Pendrill St., Vancouver, B.C., Born at Winnipeg, Man., July 27th, 1907; Educ., B.Sc. (C.E.), Univ. of Man., 1930; M.A.Sc., Univ. of Toronto, 1933; 1926-27-29 (summers), rodman and dftsman. on rly. constrn. engrg. parties, C.N.R. and C.P.R.; 1930, instr'man. and inspr., rly. constrn., C.P.R.; 1930-31, field engr. i/c welding on constrn. of steam distribution plant, Northern Public Service Corpn., Winnipeg; 1931-32, and 1933-36, field engr. on municipal improvements and constrn. city engr.'s office, Winnipeg; 1936, field and office engr., on examination, constrn., dredging and hydraulic operations, Yukon Consolidated Gold Corpn. Ltd.; at present, designing dftsman., Dominion Bridge Co., Vancouver, B.C. (*St. 1928.*)
References: A. L. Cavanagh, J. N. Finlayson, A. G. Barrett, C. R. Young, W. P. Brereton.

LEY—CECIL J., of Lachine, Que., Born at Broadcliffe, Devon, England, April 3rd, 1910; Educ., I.C.S., Dominion Bridge Evening Classes in Engrg.; 1935 to date, mech. detailer, Dominion Bridge Company, Lachine, Que. (*St. 1935.*)
References: F. Newell, R. S. Eadie, F. J. McHugh, P. G. A. Brault, H. W. Buzzell.

LOCKE—CHARLES WILLIAM EVANS, of Ocean Falls, B.C., Born at Slough, Bucks., England, May 27th, 1906; Educ., B.A.Sc., Univ. of B.C., 1930; 1924-25, mach. shop, Premier Gold Mining Co.; 1927-28 (summers), concentrator mill mtce., power house operation, with same company; 1929 (summer), rodman, leveller, transitman, Wolfe Cove Terminals, for Northern Constrn. Co., and 1930-31, asst. res. engr. on constrn. of same; 1931-32, res. engr. for contractors on Federal Govt. Dock at Three Rivers, Que.; 1934-36, Bedaux supervisor, and at present, engr. on mtce. and constrn., Pacific Mills, Ltd., Ocean Falls, B.C. (*St. 1930.*)
References: W. Smaill, E. A. Cleveland, H. F. G. Letson, W. A. Bain, W. H. Powell, H. M. Lewis.

MAHON—ALBERT GORDON, of 31 Bloomingdale Terrace, Halifax, N.S., Born at Truro, N.S., April 20th, 1907; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1929; 1929-30, test engr., Can. Gen. Elec. Co. Ltd.; 1930-35, asst. engr., Northumberland Light and Power Co., Truro; 1935 to date, asst. engr., N.S. Power Commission, Halifax, N.S. (*St. 1929.*)
References: H. S. Johnston, H. Fellows, S. L. Fultz, K. E. Whitman, H. W. Mahon.

MASON—ORLEY B., of 274 North Russell St., Sarnia, Ont., Born at Glen Falls, N.Y., Aug. 11th, 1908; Educ., B.Eng. (Mech.), McGill Univ., 1933; 1928-29-30 (summers), repair dept., Laurentide Paper Co., Grand Mere, Que.; 1931 (summer), paper tester, Crown Willamette Paper Co., Comos, Wash.; 1932 (summer), Johnson Wire Works, Montreal; with the Imperial Oil Co., Sarnia, as follows: 1933-35, machinist, dftsman., 1935-36, development engr., and 1936 to date, asst. in charge of cracking development, Development Dept. (*St. 1933.*)
References: E. M. Salter, T. Montgomery, J. W. MacDonald, E. Brown, C. M. McKergow, R. E. Jamieson.

MILLER—WILLIAM F., of 183 College St., Sudbury, Ont., Born at North Bay, Ont., Dec. 31st, 1904; Educ., B.Sc. (E.E.), Queen's Univ., 1932; 1926-29 (summers), house wiring, dfting., line constrn. and operation, and power plant operation; 1930-32, municipal engrg. dept., H.E.P.C. of Ontario, constrn., design and operation of rural electric distribution systems; Sept. 1935 to date, inspr. of electricity and gas, Dept. of Trade and Commerce, Sudbury, Ont. (testing meters and equipment for accuracy, and acceptance or rejectance of same for use in Canada). (*St. 1930.*)
References: D. M. Jemmett, L. M. Arkley, L. T. Rutledge, H. J. Kurtz, F. A. Orange.

MORRISON—J. ALEXANDER of Toronto, Ont., Born at Beaverton, Ont., Dec. 20th, 1904; Educ., B.A.Sc., Univ of Toronto, 1928; 1926 (summer), machinist, Massey Harris Co., Toronto; 1928-29, test course, 1929-31, design engr. of transformers, Can. Gen. Elec Co., Toronto; with the Consumers Gas Co., Toronto, as follows: 1931-34, industrial salesman, supervisor, industrial sales divn., April 1937 to date, director, utilization laboratory. (*St. 1928.*)
References: J. R. Cockburn, E. A Allcut, C. E. Sisson, D. C. Beam, D. S. Laidlaw.

NIX—CHARLES EDWARD, of Montreal, Que., Born at Altus, Okla., July 23rd, 1908; Educ., B.Sc. (C.E.), Univ. of Alta., 1931; 1929 (summer), rodman, C.N.R.; 1935 (8 mos.), misc. constrn., Fraser Brace Ltd.; 1930 (summer), instr'man., Northern Alberta Rlys.; 1933 (summer), instr'man., Beauharnois Constrn. Co.; 1935 (summer), supervisor for mapping parties, Geol. Survey of Canada; 1932 (8 mos.), field engr. i/c party, Shawinigan Water and Power Co.; 1935 to date, engrg. asst. to cost accountant, Shawinigan Water and Power Co., Montreal. (*St. 1929.*)
References: C. R. Lindsey, J. A. McCrory, R. E. Heartz, C. Luscombe, R. W. Boyle, R. S. L. Wilson, R. W. Ross, P. C. Kirkpatrick.

OUIMET—J. ALPHONSE, of Montreal, Que., Born at Montreal, June 12th, 1908; Educ., B.Eng., McGill Univ., 1932; Summer work: engrg. depts., Bell Telephone Company and Montreal Tramways Commn., surveying instructor, McGill Univ.; 1932-34, and 1933-35, chief reasearch engr., Canadian Television Ltd. and Canadian Electronics Ltd., Montreal; 1935-37, research engr., Candn. Radio Broadcasting Commn.; at present, operations engr., Candn. Broadcasting Corpn., Montreal, Que. (*St. 1931.*)
References: C. V. Christie, G. A. Wallace, A. Duperron, A. Frigon, B. G. Ballard, J. P. Henderson, W. A. Rush.

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References: S. Ball, M. F. Cossitt, J. K. McKay, G. S. Stairs, F. E. Saltman.

PERLSON—ELLSWORTH HARTLAND, of Edmonton, Alta., Born at Montreal, Dec. 22nd, 1906; Educ., Grad., R.M.C., 1930. B.Sc. (C.E.), McGill Univ., 1931; 1929 (summer), Dominion Engrg. Works, Lachine; Summer 1930, and 1931-33, material checker, survey party, etc., Beauharnois Construction Co., Beauharnois, Que.; since 1933, member of Royal Canadian Mounted Police, at present "On command" to the University of Alberta, proceeding to an LL.B. degree. (*St. 1930.*)
References: E. Brown, R. DeL. French, R. E. Jamieson, G. J. Dodd, M. V. Sauer, B. K. Boulton.

POOLER—GILBERT DOUGLAS, of Woodroffe, Ont., Born at Ottawa, Ont., Aug. 13th, 1906; Educ., B.Sc., Queen's Univ., 1929; 1927-28-29 (summer work), mach. shops, aeroplane dept., dfting room., Ottawa Car Mfg. Co.; 1929-30, asst. engr., Dept. Railways and Canals; 1928-29-30 (1 mo. ea.), Pilot Officer, R.C.A.F., Camp Borden; 1935 (Jan.-July), inspection dept., Fairchild Aircraft Ltd.; 1935-36, Pilot Officer, Stores Br., R.C.A.F., Camp Borden; 1937, dfting., Dom. Engrg. Co. Ltd. and Ottawa Car Mfg. Co. (*St. 1928.*)
References: D. W. McLachlan, G. A. Lindsay, J. H. Parkin, A. Ferrier.

POPE—JOSEPH MORLEY, of 61 Maple Ave., Shawinigan Falls, Que., Born at Montreal, Nov. 5th, 1906; Educ., B.Sc., McGill Univ., 1929; 1928-30 engrg. dept., Northern Electric Co.; 1930-32, engrg. dept., Canadian Marconi Co.; 1934-35, test dept., R.C.A. Victor Co.; 1935-36, with L. R. Thomson, M.E.I.C., Consltg. Engr., Montreal; 1936 to date, asst. to elect'l. engr., Belgo Divn., Consolidated Paper Corporation Ltd. (*St. 1927.*)
References: H. E. Bates, E. B. Wardle, G. B. Elliot, C. V. Christie, J. F. Plow.

REES—HOWARD SUTHERLAND, of 391 Ashbury Place, Rockcliffe Park, Ottawa, Ont., Born at Kingston, Ont., Apr. 26th, 1904; Educ., Grad., R.M.C., 1929. B.Sc. (Civil), Queen's Univ., 1929; 1929 (5 mos.), sr. dftsman., St. Lawrence Waterways, Dept. Railways and Canals; 1929-35, junior engr., aeronautics, and 1935 to date, asst. engr., aeronautics, Dept. of National Defence, Ottawa, Ont. (*St. 1928.*)
References: E. W. Stedman, A. Ferrier, E. J. C. Schmidlin, J. H. Parkin, L. F. Grant.

REINHARDT—GERARD VICTOR, of 144a 11th Ave., Lachine, Que., Born at La Have, N.S., March 20th, 1908; Educ., B.Sc. (Mech.), N.S. Tech. Coll., 1934; May 1936 to date, mech'l. designing, Dominion Bridge Co. Ltd. (*St. 1932.*)
References: R. H. Findlay, W. M. Stobbart, K. O. Whyte, M. B. Halpenny, P. G. A. Brault.

ROLLESTON—PHILIP REGINALD, of 3b Murray Ave., Quebec, Que., Born at Georgetown, Demerara, British Guiana, May 1st, 1903; Educ., 1921-23, McGill Univ., completed 2nd year engrg.; 1923-25, statistical clerk, 1925-28, meter engr., 1928-29, statistical work on production and wastes, Abitibi Power and Paper Co., Iroquois Falls, Ont.; with the Anglo-Canadian Pulp and Paper Mills, Quebec, Que. as follows: 1929-34, meter engr., 1934-36, asst. control supt., and 1936 to date, control supt. (*St. 1923.*)
References: J. O'Halloran, G. K. Addie, L. E. Goodall, E. W. McBride.

ROSS—GEORGE VICTOR, of 194 Robie St., Halifax, N.S., Born at Oxford, N.S., Mar. 22nd, 1907; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1932; 1926-28, test. dept., 1928-30, dfting. dept., Canadian Westinghouse Co., Hamilton, Ont.; 1932-33, elect'l. installn., N.S. Technical College; 1934-35, constrn., installn. of mining and milling machy., mtce., operation of milling plant, Lacey Gold Mining Co. Ltd., Chester Basin, N.S.; 1935-37, instructor in elect'l. lab. and lecturer in elect'l. subjects, N.S. Technical College; at present, asst. on preparation of valuations and appraisals, Engineering Service Co. Ltd., Halifax, N.S. (*St. 1930.*)
References: J. R. Kaye, P. A. Lovett, G. H. Burchill, S. Ball, J. D. Fraser.

ROTHWELL—JAMES MOSCRIP, of 3475-West 18th Ave., Vancouver, B.C., Born at Walkerton, Ont. Feb. 6th, 1896; Educ., B.Sc. (Civil), Univ. of B.C., 1927; Summers: 1923, rodman, city of Vancouver; 1924, instr'man., B.C. coast triangulation; 1925, rodman, City of Vancouver; 1926, tidal current survey, Vancouver and District Joint Sewerage and Drainage Board; 1926-27, instructor, summer school of surveying, Univ. of B.C.; 1927-28, instr'man. on location of water mains and tunnels, Greater Vancouver Water District; 1928 to date, senior instr'man., survey dept., City Engr.'s Office, Vancouver, B.C. (*St. 1927.*)
References: E. A. Cleveland, C. Brackenridge, R. Rome, W. H. Powell, W. B. Greig.

SHANKS—VICTOR, of 2 LeRoy Ave., Toronto, Ont., Born at Portadown, Nor. Ireland, June 14th, 1910; Educ., B.A.Sc., Univ. of Toronto, 1935; 1935-36, mech. dftsman and designer, Gutta Percha and Rubber Ltd., Toronto; at present, elect'l. laboratory asst., Sangamo Electric Co., Toronto. (*St. 1932.*)
References: R. E. Smythe, W. P. Dobson, O. Holden, J. R. Montague, R. W. Angus, C. H. Mitchell.

SILVER—RALPH CHARLES, of Ottawa, Ont., Born at Danville, Que., Sept. 15th, 1904; Educ., B.Sc., 1927, M.Sc., 1929, McGill Univ.; 1926, summer work with Shawinigan Company; 1927-29, demonstrator, McGill Univ.; with the Gatineau Power Co. as follows: elect'l. engrg. dept., on relay calculations, layouts and installns., 1934-35, relay engr., and 1935 to date, protection engr. (*St. 1926.*)
References: C. V. Christie, W. G. C. Gliddon, G. G. Gale, J. Woodside, P. Ackerman, G. A. Wallace, G. H. Desbarats.

SOLES—WILLIAM ENGLAND, of Chandler, Que., Born at Derby Line, Vt., July 2nd, 1912; Educ., B.Sc. (Mech.), Queen's Univ., 1935; 1935-36, statistical work connected with production and operation control, Anglo-Canadian Pulp and Paper Mills, and 1936-37 (4 mos), i/c meters and control instruments for same company; at present, control dept., Gaspesia Sulphite Co., Chandler, Que. (*St. 1935.*)
References: L. M. Arkley, L. T. Rutledge, D. S. Ellis.

SOMERS—CLAUDE JUDSON, of 7 Yates Ave., Cornwall, Ont., Born at Moncton, N.B., Mar. 19th, 1910; Educ., B.Sc. (Civil), Univ. of N.B., 1936; 1934 (summer), road constrn. Raynor Constrn. Co., Toronto; 1935 (4 mos), junior inspr., 1936 (8 mos), senior inspr., Milton Hersey Co. Ltd., Montreal; 1937 (6 mos), dftsman., and at present field engr., Howard Smith Paper Mills, Cornwall, Ont. (*St. 1936.*)
References: E. O. Turner, A. F. Baird, J. Stephens, M. F. Macnaughton, H. E. Meadd.

STADLER—JOHN CHARLES, of Montreal, Que., Born at Shawinigan Falls, Que., Oct. 6th, 1906; Educ., B.Sc., McGill Univ., 1931; 1928 (summer), power development survey; 1932-36, gen. office and engrg., with John Stadler M.E.I.C.; 1936, asst. sec'y., responsible for link between engrg. and secretarial offices, Quebec Electricity Commn.; at present, station manager, CRCM-CBF, Canadian Broadcasting Commission, Montreal, Que. (*St. 1927.*)
References: J. Stadler, F. M. Wood, W. I. Bishop, A. Frigon, O. O. Lefebvre.

STANFIELD—JOHN YORSTON, of 17879 Gouin Blvd., St. Genevieve, Que., Born at Truro, N.S., Aug. 17th, 1908; Educ., Grad., R.M.C. B.Sc. (C.E.), 1932, B.Sc. (M.E.), 1933, N.S. Tech. Coll.; 1930-31, Montreal Terminals development mtce. man, and inspr.; 1935-36, dftsman., 1936-37, asst. master mechanic, Cons. Paper Corpn., Shawinigan Falls, Que.; at present, Canadian representative, Anti-Hydro Waterproofing Co., Newark, N.J. (*St. 1932.*)
References: H. E. Bates, E. B. Wardle, F. W. Bradshaw, L. F. Grant, S. Ball.

TUCK—JOSEPH HOWARD, of Port Colborne, Ont., Born at Port Colborne, Ont., July 23rd, 1909; Educ., B.Sc., Queen's Univ., 1932; 1927-31 (summers), machine shop, International Nickel Co,; 1931 (6 mos.), estimating, Buffalo Forge Co., Buffalo; 1932-36, i/c time study work and labour control under Bedaux system with Campbell Soup Co., New Toronto; 1936-37, first as machinist with International Nickel Co., and now as understudy to supt., Whitehead Metal Products of Canada, Port Colborne, Ont. (*St. 1928.*)
References: L. M. Arkley, L. T. Rutledge, R. E. Smythe, C. N. Geale E. P. Murphy.

WALKEM—RICHARD of Vancouver, B.C., Born at Vancouver, Feb. 23rd, 1910; Educ., Grad., R.M.C., 1932; 6 mos. machine shop, Vancouver Machinery Depot; 1933 to date, with the Vancouver Iron Works, Vancouver, B.C. Three years ap't ceship in boiler shop, shop supt., and at present on the office staff. (*St. 1929.*)
References: W. T. Fraser, J. Robertson, E. A. Cleveland, E. A. Wheatley, A. S. Gentles.

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# THE ENGINEERING JOURNAL

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## Business Management and the Scientific Point of View*

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**An Address delivered before the Montreal Branch of The Engineering Institute of Canada on April 29th, 1937.**

SUMMARY.—The address discusses the application of scientific methods to the direction of business enterprises, more particularly as regards the four principal activities, planning, organizing, co-ordination and control. A number of specific problems are mentioned as coming under the four major headings. The qualifications necessary for a scientific business executive are indicated and attention is drawn to the scope and importance of possible economies in management which should result from a scientific attitude on the part of executives.

In his book, "The Last Puritan," which he describes as a memoir in the form of a novel, George Santayana, the philosopher, makes a young German governess express her opinion of American business men in the following terms, which she employs in a letter written to her sister:

> ". . . they hate to think. They are too busy, too tired: or if they half form an opinion in spite of themselves, they won't take the trouble to express it accurately, or to defend it. They laugh at what people *think*, even at what they think themselves, and respect only what people *do*. Yes, my dear, and beneath that horrid cynical scepticism, there is something deeper still. They are *afraid of the truth*."

Certainly this is not a flattering picture of American business men. Doubtless the young governess, in penning her delineation, was not conscious that, although she might perhaps with propriety single out American business men for special emphasis in this connection, she had made an observation which is well-nigh universal in its application.

After long experience in dealing with business men in a number of countries, it has been borne in upon me that they do not, generally speaking, think in fundamental terms. Most of them are technicians, familiar with the traditions, procedures and problems of the functions within which their experience has been generated. In other words, all their thinking has been vertical, and they have not acquired the habit of thinking horizontally, which is a pre-requisite to successful exercise of the responsibilities associated with the direction of a business enterprise.

Under present-day economic conditions, when business appears to be ground between the upper mill-stone of the demand of labour for an increasing return upon its effort, and the nether mill-stone of the need for lowering prices to the consumer—the only way in which greater distribution of goods can be achieved—the necessity for thinking in fundamental terms about the internal and external problems of business is more urgent than ever.

When those in charge of this programme requested me to suggest a subject that would prove fitting for discussion on this occasion, reflections such as these convinced me that it would be appropriate to select "business management" as the broad, general background of my address, and to stress in that connection the validity and importance of the scientific point of view.

During the past two or three decades, business management has gradually become exposed to the influences emanating from the application of the rule of science. In the rapidly changing world of today, all fields of human endeavour are more and more experiencing the impact upon existing conditions of the concrete results produced by the genius of the scientific mind; wherever we turn, we are faced with the dynamics of a new and unprecedented order of things which demands both readjustment and control. In the business world, progress can be made only by so plotting a course through a sea of uncertainties as to avoid the Scylla of ignorance, extravagance, prejudice, discord, incompetence and vacillation, on the one hand, and, on the other, to steer clear of the Charybdis of over-organization, greed for profit, ruthless competition, economic illiteracy, unparalleled size and autocratic dominance.

While it must be recognized that science can be of benefit to mankind only if the discoveries it makes available are exploited in behalf of advancement of the common good, we may postulate that the scientific point of view—the habit of thought that scorns to employ in the solution of problems any process except the scientific method—should be an important, if not indispensable, part of the mental equipment of all persons truly desirous of making contributions of permanent value to the advancement of business management.

May I add to these introductory remarks two statements which seem apposite to me? First, I wish to point out that the implications of the theme which I have chosen are constantly pervading my professional and avocational activities; I am, therefore, happy to have the opportunity of sharing with this audience the product of my experience, thought and study with respect to them. Secondly, it is my considered judgment that in her development toward higher planes of economic and social accomplishment, Canada occupies a position of importance in which she is able to make a contribution of marked value to the advancement of management, and, *per contra*, to benefit from further application of the art and science in the cause of her industrial, commercial, financial and technical progress.

### WHAT IS THE SCIENTIFIC POINT OF VIEW?

I have previously indicated that science and the scientific method are entering gradually into the field of business management. A business executive who does his work scientifically is more valuable to his company than one who, however well he may be natively endowed, allows rule-of-thumb methods and unsupported thinking to permeate his activities.

What is the scientific point of view? In order to answer this question, we must first define the word "science."

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In his scholarly work, "The Organization of Knowledge,"[1] Bliss describes science as "verified and organized knowledge, analytic and synthetic, rationally and methodically proceeding from experiential data and perceptual relations to generalizations, theories, laws, and principles, and to conceptual systems."

If we turn to some of the great mathematicians of the past, men whose genius of intellect enabled them to penetrate the mysteries of science and to reveal them to the astounded gaze of mankind, we find in their writings illuminating sidelights on the meaning and basis of science. So, for example, Sir Francis Galton, who expressed the firm belief that "until the phenomena of any branch of knowledge have been submitted to measurement and number, it cannot assume the dignity of a science."[2] And this statement, made and often repeated by Adolphe Quetelet, Belgian astronomer and statistician, is of similar import: "The more advanced the sciences have become, the more they have tended to enter the domain of mathematics, which is a sort of centre towards which they converge. We can judge of the perfection to which a science has come by the facility, more or less great, with which it may be approached by calculation."[3]

Science, then, is organized knowledge which has been submitted to the acid test of measurement and verification. It is not a hodge-podge of facts brought together in more or less related order; it is knowledge acquired through research, supported by utilization of the scientific method, i.e., observation, experimentation and formulation of verifiable law.

In his great work, "An Introduction to the Study of Experimental Medicine," Claude Bernard, the famous French physiologist, contemporary of Pasteur and member of the Académie Française, put the case for science in this fashion:

> "By simply noting facts, we can never succeed in establishing a science. Pile up facts or observations, we shall be none the wiser. To learn, we must necessarily reason about what we have observed, compare the facts and judge them by other facts used as controls. But one observation may serve as control for another observation, so that a science of observation is simply a science made up of observations, i.e., a science in which we reason about facts observed in their natural state, as we have already defined them. An experimental science, or science of experimentation, is a science made up of experiments, i.e., one in which we reason on experimental facts found in conditions created and determined by the experimenter himself."[4]

With these interpretations of the significance of science before us, we are better prepared to analyze the meaning of the scientific point of view; in fact, the quotations given have assisted in answering, at least partly, our query on that subject. It is evident that a point of view, to be characterized as scientific, must be dominated by the desire to discover the truth, or, as we are apt to say in every-day parlance, to get at the facts. Unfortunately, however, for the cause of science in business, much of what passes for fact is produced by methods which, to say the least, are open to grave question, because quantitative analysis, based on measurement, has played no part in them. "Until measurement is possible in a science," writes Mills, "it is unavoidable that its observations and findings should lack precision, no matter how brilliant the flashes of intuition or how painstaking the labours of its students may be."[5]

The scientific point of view, then, rests firmly upon the foundation of research, supported by the scientific method; in approaching the solution of problems in a chosen field of investigation, it rigorously excludes from consideration, and scorns to employ, any method which is not in harmony with the tenets of science. At the risk of quoting unduly from Bernard, whose "Experimental Medicine" constitutes an illuminating revelation of the mental processes of a great scientific investigator, permit me to read these additional paragraphs:

"The true scientist is one whose work includes both experimental theory and experimental practice. (1) He notes a fact; (2) apropos of this fact, an idea is born in his mind; (3) in the light of this idea, he reasons, devises an experiment, imagines and brings to pass its material conditions; (4) from this experiment, new phenomena result which must be observed, and so on and so forth. The mind of a scientist is always placed, as it were, between two observations; one which serves as a starting point for reasoning, and the other which serves as conclusion."[6] Finally, Bernard holds that "scientific generalization must proceed from particular facts to principles; and the principles are the more stable as they rest on deeper details, just as a stake is the firmer, the farther it is driven into the ground."[7]

Without wishing to extend this discussion of the scientific point of view, I cannot resist the temptation of referring to certain lofty thoughts and eternal truths which have been eloquently expressed by great leaders in different departments of human knowledge when endeavouring to interpret the spirit of science and the real meaning of the scientific approach to the solution of fundamental problems.

Ruskin once said that "the work of science is to substitute facts for appearances and demonstrations for impressions." Goethe asserted, with that calm, clear vision which characterized the poet-philosopher, that "we see only what we know." Huxley expressed the belief that science is nothing but trained and organized common sense. On one occasion he also spoke of "the great tragedy of science—the slaying of a beautiful hypothesis by an ugly fact." Whitehead alleged that "it is no paradox to say that in our most theoretical moods we may be nearest to our most practical applications." Marcus Aurelius concluded that "nothing is so productive of elevation of mind as to be able to examine methodically and truly every object which is presented to thee in life."

And last, Poincaré, perhaps the greatest mathematical philosopher of modern times. In an essay on "Science and Reality," he reveals one of those brilliant flashes of intellect of which only a genius of the first order is capable. In stressing the value of devotion to science for its own sake, he concludes with this profound observation:

> "All that is not thought is pure nothingness; since we can think only thoughts and all the words we use to speak of things can express only thoughts, to say there is something other than thought, is therefore an affirmation which can have no meaning. And yet—strange contradiction for those who believe in time—geologic history shows us that life is only a short episode between two eternities of death, and that, even in this episode, conscious thought has lasted and will last only a moment. Thought is only a gleam in the midst of a long night. But it is this gleam which is everything."[8]

Much as we may admire the scientific point of view and acknowledge it as one of the chief causative factors in the advancement of civilization throughout the ages, we are forced to recognize the comparatively limited extent to which, after all, it pervades business today. Unlike the college professor who in a burst of scientific

[1] Bliss, H. E., The Organization of Knowledge, p. 190. Henry Holt and Company, New York, 1929.

[2] See Walker, Helen M., Studies in the History of Statistical Method, p. 46. Williams and Wilkins Company, Baltimore, 1929.

[3] Ibid., p. 39.

[4] Bernard, Claude. An Introduction to the Study of Experimental Medicine, p. 16; translated by H. C. Greene. Macmillan Co., New York, 1927

[5] Mills, F. C., Statistical Methods, p. 9. Henry Holt and Company, New York, 1924.

[6] op. cit., p. 24.

[7] Ibid., p. 26.

[8] Poincaré, H., The Foundations of Science, p. 355; translated by G. B. Halstead. The Science Press, New York, 1929.

fervour expressed the hope that his subject might never become practical, we should regard it as greatly to be desired that the bond between science and business be strengthened as time passes, so that ultimately business men, discerning the wisdom of this union, will never fail to explore in truly scientific fashion the foundations upon which all sound accomplishment must inevitably rest.

### WHAT IS BUSINESS MANAGEMENT?

In order to facilitate understanding of what is to follow, it is desirable to set forth initially a definition of the term, "business management."

Despite the many definitions advanced by others, I have elected to define management as "the direction of a business enterprise, through the planning, organizing, co-ordinating and controlling of its human and material resources, toward the achievement of a predetermined objective." This definition, it will be seen, places the emphasis upon the dynamic aspects of management; in other words, it views management as an art, but, it should be added, with complete acceptance of the scientific foundations upon which the art must rest.

It will be observed from the definition that the master-function of direction sub-divides itself into the four functions of planning, organizing, co-ordinating and controlling. Broadly speaking, the first of these functions concerns itself with the formulation of a programme of action, based upon present and probable future requirements and conditions; the second involves combination, development and adaptation of all appropriate structural elements; the third addresses itself to the establishment of sound integration, co-operation and motivation, and the fourth is concerned with the measurement of performance, supervision and maintenance of standards.

Within the compass of the activities of a single enterprise, planning, organizing, co-ordinating and controlling, which are the *sine qua non* of management, must be applied first to the master objective of the enterprise, then to the major divisions of finance, production, distribution and facilitation, and then through the greater and lesser organization sub-divisions to the last worker on the smallest operation.

When formulating a concept of planning, mental processes concern themselves readily and naturally with the establishment of the best methods, the creation of standards of work and cost, and the scheduling of operations. To give practical expression to this concept, it is usual to apply it primarily to the discovery and introduction of the most effective methods of performance, and to utilize in this connection such quantitative measures of volume, cost and time as will lead to increasingly effective and economical operating results.

Much thought and study have been devoted to the problems involved in the discovery of the best or most effective methods. In fact, many proponents of improvement in the art of management have allowed their advocacy thereof to crystallize in the statement that a controlling consideration is the determination of the "one best way." As a contention, this statement is entitled to weight, but in practice it must always be surrounded by marked qualifications. Under the dynamic conditions amid which the art of management is exercised, the one best way must constantly be modified by an enormous number of variables, of which there need be emphasized only the elements of organization, personnel, equipment, volume, cost and time. Determination of the one best way resolves itself, then, into a constant readjustment of such elements to changing conditions, which becomes, in almost every instance, a continuous process. It is this aspect of planning with respect to methods that must be stressed, for only too frequently the fallacy involved in adherence to a supposedly best way is not discerned until long after methods have crystallized into a routine which gradually and persistently departs more and more from correct requirements.

Quantitative measures of volume, cost and time are tools which, when properly employed, constitute great aids in advancing the art and science of management. From the point of view of planning, the element of volume presents a most important and difficult problem. Material fluctuations are present even in normal times; during periods of depression, they are either supplemented or altogether replaced by marked downward trends. In either case, planning implies the most effective readjustment of operating conditions to the current and prospective volumes of work, as expressed quantitatively in appropriate units of measurement. With regard to the elements of cost and time, these are in some respects fixed and in other respects variable, and because of this fact they must be given constant attention. Planning has for its objective the attainment of that level of performance which is in harmony with valid standards in terms of volume, cost and time.

Within the limits here discussed, planning may be described, broadly, as a function which leans heavily on the processes of analysis, simplification and standardization. The first of these, scientifically undertaken, constitutes the correct approach to investigation of existing conditions; the second frankly recognizes and adjusts itself to the constant need for elimination, revision and improvement of steps in the procedures, and for modifications in the equipment necessary to achieve the objectives involved; the third represents the constant striving for perfection which is so ancient a characteristic of human endeavour. Analysis, simplification and standardization, in effect, set the stage for purposeful planning as applied to the erection of adequate foundations required by other divisions of the function of direction.

When formulating a concept of organizing, it should first of all be recognized that underlying every form of business enterprise there will be found an organization structure, or framework, which is designed to provide the necessary foundation for the activities to be carried on. In comparatively rare instances will the structure be well adapted to the attainment of the objectives it is intended to promote. More often it will turn out to be fixed or rigid in character, and lagging far behind current conditions and requirements. Indeed, in numerous instances the structure will be so poorly devised that it will constitute a formidable interference with constructive accomplishment.

Now, it cannot be too often emphasized that organization is but a means to an end, and not the end in itself. It is a continuous process that depends for its success upon the maintenance of such degrees of combination, development and adaptation of the structural elements as will keep the business machine moving swiftly, surely, and without frictional losses, toward its appointed objective. Sound organization expresses recognition of the fact that purpose and conditions are controlling considerations, and that the design of the structure must be adapted to them.

Analysis of the influence of organizing upon accomplishment at first leads to the conclusion that at all stages of size of a business enterprise a plan of organization can be devised that will adapt itself effectively to existing requirements. But when one probes farther into the question, it often becomes apparent that where adaptation to requirements exists, it has been the resultant, not of a conscious process of organizing, but mainly of fortuitous circumstances. It will be recognized that the influence of the factor of personnel in shaping the process is great; where one encounters instances of sound conditions of organization, it frequently turns out that they are referable to a welding of the human elements that has proceeded without the assistance of a well-ordered plan, and has been dominated by psychological adjustments of varied character.

Study of the organization structures of hundreds of business enterprises, both in America and abroad, has convinced me that in many instances they reflect the forces of personality and power rather than the logic and strength of proper structural relationships. In this fact lies the explanation for the ultimate arrival of such enterprises at a plateau of progress from which emergence more often follows a downward than an upward curve. That a business cannot permanently occupy levels of effectiveness higher than those clearly determined by the capacity of its executives is self-evident, but it is not generally understood that the influence of superior organization upon the accomplishments of mediocre executives can raise the enterprise to heights not otherwise attainable.

Experience has shown that such organization faults as over-elaboration, unwarranted subdivision of activities, unjustifiable extremes of functionalization, excessive departmentalization, and others that could be cited, are important contributing factors to the failure of many businesses to achieve sound conditions of development. Their influence is subtle and not easily discerned; it is made more compelling by the fact that even where there is the will to organize soundly, this is often frustrated by a clash between the points of view of ownership and management—especially when the two roles are merged in one and the same person or group—with ownership usually dominant, and scant regard accorded to such abstract considerations as sound principles of organization.

Co-ordinating, as already stated, has to do with the establishment of sound integration, co-operation and motivation. Perhaps the most important aspect of the problems involved in co-ordinating the activities of a business enterprise is the integration of line and staff functions, or, in other words, integrating the work of the persons responsible for operating results with that of the persons who act in an advisory capacity.

The interaction of line and staff often produces situations of extremely delicate character, requiring skilful handling and experience in the art of intelligent compromise. Regardless of how clearly defined are the lines of demarcation between functions and individual spheres of activity, there is unfortunately a widespread tendency in business institutions for executives gradually to depart from any scheme of organization laid down. Moreover, conflicts of personality, which are of frequent occurrence, tend in the long run to lead to a blurring of functions, to competing jurisdiction over the same subject matter, and to the forcing of the organization pattern into distortions which correspond roughly to the degree of aggressiveness, or lack of it, displayed by executives in various important positions. Dealing successfully with situations of this kind involves utilizing every factor adaptable to integration and to the advancement of the interests of the organization as a whole.

Every attempt at co-ordination through proper integration and adjustment, brings the opportunity, indeed the necessity, for co-operation. Co-operation is a binding process which should pervade every activity of the organization. Practically every act of management requires for its consummation that co-operative relationships be maintained between two or more persons. Here arises, however, the need for determining just what co-operation involves. It is not difficult to secure general agreement to the statement that management should so perform its function as to be sure that adequate co-operation will exist. The problem is to determine the best methods of bringing about these relationships.

The existence of co-operation depends primarily upon the setting by top executives of an example which may be found worthy of emulation by other members of the organization. It is, of course, true that business organizations cannot be kept moving forward at the requisite rate of speed by maintaining the town-hall meeting brand of management, or by attempting to secure universal agreement to a proposition before it is adopted. Particularly in disturbed times, it is essential that management keep a firm hand on the helm and demonstrate its ability to issue specific orders and exact prompt and willing obedience thereto. It is not, however, inconsistent with this need that a decent regard be had for the points of view of all whose opinions may contribute something worthwhile to the progress of the institution.

The acid test of the existence of true co-operation is the presence of a twofold relationship of loyalty—loyalty to his superior on the part of the subordinate and loyalty to his subordinate on the part of the superior. If this relation of mutual confidence exists, the result, in practical terms, spells the finest type of co-operation.

The preceding statements lead naturally to a brief consideration of the subject of motivation. Effective stimulation of human beings is among the most powerful agencies which may be utilized to further the aims of a business enterprise, or any other human undertaking. Executives and employees alike respond readily to the right stimuli. An understanding and alert management will easily discover practical methods of motivating its subordinates so that their desire for worthwhile accomplishment will express itself dynamically.

The essentials of co-ordinating, it may be said, consist of a process of adjusting material and human resources to a soundly integrated organization structure, a process which is dependent for effective operating results upon methods of co-operation and motivation that denote morale, esprit de corps and leadership.

Finally, what can be said by way of interpretation of the function of controlling, the fourth and last to be considered? There is hardly a word in the terminology of management which is used with so many and such widely differing applications. The owners of a business possess *control* over its material and human resources; when bankers step into the picture, *control* is said to pass into their hands; administration and management usually have the power to exercise *control* over operations; the financial affairs of an organization are *controlled* through the budget; *control* over production is largely a function of the planning department; the activities of salesmen are *controlled* by the sales manager; *control* over office operations is the responsibility of the office manager.

For present purposes, a restricted interpretation of the concept of control will in no sense detract from its importance; hence, it is postulated that we are here dealing with a terminal function which concerns itself, as previously indicated, with measurement of performance, supervision, and maintenance of standards. Thus it will be seen that control is a dynamic concept, and that in operation it tends to keep the enterprise upon the appointed course, to provide it with the proper momentum, to determine its rate of progress, and to evaluate the operating results produced.

The onward march of industry, from small beginnings to great size, has been accompanied at all stages by perplexing questions of control. Indeed, in the period which has elapsed since the turn of the century, such questions have assumed particular prominence in view of the magnitude and complexity of the great corporations which have become characteristic of the economic order in which we live. It is widely recognized by students of the problem that human development has not kept pace with corporate size, and that, therefore, even the most finely conceived processes of control as yet made available are inadequate for the purpose of determining, achieving, and maintaining optimal conditions. While the last word has not yet been said upon this subject, it is certainly demonstrable that when institutions such as banks, life insurance companies, public utilities, mail order houses, department stores, and great concerns in industrial fields pass a certain stage in their development, something seems to happen to them that is in the nature of decreasing success, if not, indeed, of pronounced loss.

It is impossible to generalize with respect to the causes responsible for such reversals, but we do know that supervision often breaks down because it is placed in the hands of technicians whose ability to deal with *things* far outweighs their capacity for controlling the *human beings* for whose success they are responsible. Moreover, we are aware that, despite the era of science in which we are living, comparatively little has been done in the field of measuring performance in general, and practically nothing in evaluating scientifically the results produced by comparable groups of executives. As for maintenance of standards, rarely are executives furnished with valid norms, qualitatively and quantitatively expressed, and hardly ever is recognition given to the need for differentiating adequately between controllable and non-controllable conditions affecting performance. It is a regrettable fact that these shortcomings exist; to a great extent they are preventable, but I question whether much progress will be made with their eradication until a new generation of executives appears upon the scene, endowed with sufficient intelligence and scientific training to understand, accept, and practice the principles underlying sound methods of control.

### WHAT ARE SOME OF THE SPECIFIC PROBLEMS TO BE SOLVED?

The first step in the application of the scientific viewpoint to business management, consists of realization of the fact that only through controlled investigation, experimentation and the building up of a body of verified principles, can management emerge from the trial and error stage to the attainment of certain and effective results. If management is to be intelligently and purposefully exercised, it must visualize the area with which it has to deal, must isolate all of the forces within that area which are operating for or against the attainment of the desired results, and must, above all, learn to cope with many specific problems whose existence and nature can be discerned only by penetrating scientific analysis.

What are the problems which confront business management in seeking to achieve a predetermined objective? Bearing in mind the four functions previously stated, namely, planning, organizing, co-ordinating, and controlling, let me call attention briefly, under these headings, to some of the problems with which management is bound to concern itself, even in progressive and apparently well organized institutions:

A. *With Respect to Planning*

Analysis

1. To what extent does useless work exist and how can it be eliminated?
2. What is the most effective manner of reducing peak loads?
3. Has each position in the organization been analyzed as to work performed and qualifications of worker?
4. Do space arrangements obstruct or promote the proper flow of work?

Simplification

5. What policy should govern the destruction of old records?
6. Has "paper" work been reduced to a minimum?
7. Can any operations be combined to advantage with others?
8. Can any operations be more advantageously performed by outside organizations?

Standardization

9. Are there any limits to the value of mechanization?
10. Have all forms and records in use been properly standardized?
11. Is there in existence an effective system of control over the origin, revision and elimination of printed forms?
12. Is uniformity of equipment carried throughout the organization?

B. *With Respect to Organizing*

Combination

13. To what extent are service functions centralized?
14. Is ultimate control centralized?
15. Is a centralized personnel department in existence?
16. Is a centralized planning department in existence?

Development

17. How far can work be advantageously subdivided?
18. Have changes in size been accompanied by the necessary fundamental changes in organization?
19. Has development of the organization structure been warped or restricted to conform to individual attributes of the executive personnel?
20. How many levels of authority are present in the organization structure?

Adaptation

21. To what extent is it advisable to change operations from a sequential to a simultaneous basis of performance?
22. Do the duties assigned to each executive call forth his best ability and engage his entire time?
23. Is any executive overburdened with duties?
24. Is authority placed as closely as possible to the point where action originates?

C. *With Respect to Co-ordinating*

Integration

25. Are the relations between staff and operating departments promotive of superior operating results?
26. Is authority clearly defined and allocated?
27. Is authority to make important decisions placed in competent hands?
28. Are all activities effectively co-ordinated?

Co-operation

29. Have executives and supervisors an organization viewpoint, rather than a departmental viewpoint?
30. Are systematic training procedures employed?
31. Are adequate measures taken to maintain high standards of health among employees?
32. Are suitable and comfortable working conditions provided?

Motivation

33. What is the most effective type of financial or non-financial incentive to be utilized in a given situation?
34. To what extent is it advisable to invite suggestions from employees?
35. How can the fetish of seniority be abolished?
36. What is the relation between remuneration and length of service?

D. *With Respect to Controlling*

Measurement

37. What is a fair day's work in given occupations?
38. What should be the elapsed time for given cycles of work?

39. How can this period, once established, be controlled?
40. Is each department measured on a profit and loss basis?
41. Is the performance of each individual executive measured?

Supervision

42. What is the relation of supervision to increased production?
43. How can the optimal degree of supervision be ascertained?
44. How many levels of supervision are in effect?
45. Is planning separated from performance?

Maintenance of Standards

46. What is the best method of checking given types of work?
47. How far should the checking process be carried?
48. How can detailed information best be transformed into control information?
49. Are satisfactory standards developed for measuring financial results?
50. Is the cost of compiling statistics and reports kept within justifiable bounds?

Comparatively simple as many of these questions seem to be, there will be found lurking in their implications vast areas for the application of intelligent investigation by means of the scientific method. Questions such as those that I have posed, and literally scores of others that can be cited, comprise the dynamics that attach to the performance of the task of management under present-day conditions.

The fact that I have cited the foregoing problems is not to be construed as an indication of the belief on my part that they have not, to some extent, been made the subject of scientific inquiry, or that gratifying results have not often followed such individual researches. From broad experience in dealing with the problems of business management during the past two or three decades, however, the opinion may be ventured that, generally speaking, application of the scientific method to that field still lags far behind by comparison with such developments as have occurred in the sciences.

The reasons for this condition are not far to seek. In the realm of management, planning and performance have been constantly intermingled, with the result that the former has been obliged to suffer because of the current claims of the latter. In the second place, adjustment to the impact of hostile economic conditions has claimed so much of the time and effort of major executives, especially in recent years, that, strange as it may seem, the activities comprised in management have not been able successfully to vie with them for attention. Moreover, until recently the view has been widespread that management is not susceptible of measurement. This view is happily being dissipated, largely through increased awareness of the need for operating successfully in ever narrower margins set by economic conditions.

In order to raise management to the level of progress attained by other arts and sciences, and to introduce conditions which will lend themselves to effective control, we are forced to the conclusion that a scientific approach to the solution of its problems must be undertaken in an organized manner. From the practical point of view, this means that the task of management must be entrusted to individuals who have a thorough knowledge and appreciation of the scientific point of view, together with the capacity to translate these into effective action.

## WHAT QUALIFICATIONS MUST THE SCIENTIFIC BUSINESS EXECUTIVE POSSESS?

It will readily be deduced from what has been said that, in the last analysis, the problem involved in introducing the scientific point of view into management becomes, apart from certain impersonal aspects, an individual one, and that the attributes of the executives concerned constitute important, if not controlling, elements in its solution.

Some individuals are possessed of the scientific point of view; others are not. Some have the ability and inclination to acquire it; others could never conform to its rigorous demands. The type of executive who dismisses science with a snort of contempt and boasts of the possession of so-called "practical" qualities, is still far from rare in business.

Since the application of the scientific point of view to management seems to depend so much upon personal temperament and capacity, it may prove interesting, if not useful, at this point to describe some of the more important qualifications which, in my judgment, in addition to technical capacity, enter into the make-up of what may be termed the scientific business executive. I submit these qualifications as representing purely my personal viewpoint, and I surmise that there may be many in this audience who will disagree; that is their privilege.

The scientific business executive is he who possesses, among other characteristics, the following:

1. A strictly impersonal viewpoint;
2. The ability to think in terms of management;
3. A passion for truth as revealed by the methods of science and research;
4. Adequate training in sound methodology and thorough grasp of modern statistical methods;
5. An ample cultural background;
6. An attitude of philosophic doubt;
7. Devotion to bibliochresis, i.e., the scientific use of literature;
8. A spirit of co-operation with other workers in the field, as well as with members of his own organization;
9. Success in the art of self-interpretation;
10. The saving grace of humour.

"True science," it has been said, "has no fetishes that it clings to in the face of evidence."[9] Therefore, in the application of his energies to the solution of the problems confronting him, the scientific business executive may always feel confident that faithful pursuit of his objectives will lead inevitably to enduring satisfaction through sound accomplishment.

What opportunities are available to executives and to those who aspire to such positions, to prepare themselves for serious work of lasting value in their chosen field of vocational effort? There are, first of all, the courses of formal training given by schools of business and similar institutions whose aim it is to equip their students with technical knowledge, joined to a firm grasp of principles, in the fields covered by their curricula. Most of the older schools of business do excellent work of high grade; those who are fortunate enough to be so situated as to be able to enrol as students and to complete the courses offered, usually secure a training which proves a decided asset throughout their business careers. Next in line are the institutions which aim by means of the correspondence method to teach students who for various reasons cannot arrange to attend residence schools of instruction. There are at least two so-called "correspondence" schools with whose text books and methods of instruction I am sufficiently familiar to be able to say that the courses in management offered by them are comprehensive and thorough and, if faithfully pursued, are bound to equip the student with

[9] Kelley, Truman L., The Scientific versus the Philosophic Approach to the Novel Problem; Science, Vol. LXXI, No. 1838. The Science Press, New York, March 21, 1930.

knowledge of practical value in fitting himself for an executive position.

But what of the executive, or junior aspiring to such a position, who devotes his entire time to the performance of his business duties and finds an extended course of training incompatible with the demands made upon him by his daily work? To such a man who is ambitious to explore his chosen field of effort and to equip himself for greater responsibilities, an avocational interest of major consequence and lasting value is presented through membership in organizations such as those represented here tonight. Many questions of importance to executives are discussed at the forums which these organizations regularly provide; in fact, I doubt not that a search through the published proceedings of these professional bodies would disclose that a number of the questions which I have propounded have been made the subject of careful inquiry and report.

Perhaps the greatest benefit of membership comes, however, in the opportunities afforded for personal mingling with men and women of similar experiences and interests, and for participation in the discussions that constitute so vital and practical a feature of the meetings. The pooled knowledge of the entire group is always at the disposal of the individual member; on occasion eminent authorities appear to discuss the burning questions of the moment; the records of their presentations and of the ensuing discussions, form an indispensable part of the source material which every aspiring business executive will wish to preserve.

A distinguished American statesman once said in effect that every man owes of his time and effort to the profession to which he belongs. If I have made any progress at all in my profession of management engineer, it is primarily and chiefly because for over a generation I have consciously elected to expose myself to the constructive and stimulating influences that pervade the scientific organizations, both here and abroad, in which I am privileged to hold membership. I have come to attach so great a degree of importance to such membership as a criterion of the capacity, standing and worth of an individual, that whenever it becomes my responsibility to judge persons who offer themselves for consideration as candidates for high executive positions, this test is invariably among the first to be applied.

## CONCLUSION

Before bringing this address to a close, it may be appropriate to visualize for a moment the great and growing importance of the field of business management, in order to give point to the observation that effective management is among the objectives to the achievement of which business and government should purposefully and persistently address themselves. Let us look at just one branch of management for illustrative material.

While exact figures unfortunately are not available, I venture to express the belief that approximately five millions of office workers are at present employed in the States. Of these, several hundreds of thousands are in governmental service. Assuming an average salary of $1,000 per annum (a conservative estimate, I feel sure), the total annual payroll would amount to five billions of dollars. Statement of this figure leads to keen speculation as to the justification for so large a disbursement of money for what is often inelegantly, but not altogether inappropriately, described as "paper work."

With great regard and entire sympathy for the human values involved, I am of the opinion that a horizontal saving of at least 10 per cent of this amount, or $500,000,000 per annum, is easily within the realm of accomplishment, through the application of sound principles and techniques of management. In addition to such a saving, there are of course uncounted millions of dollars of collateral economies that would flow from items such as rent, equipment, supplies, etc., which would be scaled down in proportion.

Unless the time honoured point of view of the engineer is to be wholly subordinated to the onward sweep of the new doctrines enunciated by the sociologist, the politician and the labour leader, it seems reasonable to assume that something should be done to take advantage of the unparalleled opportunity which the figures just recited apparently make available. There must of course be developed as a prerequisite to accomplishment, a sane appreciation of the worthwhileness of securing the savings, for until current tendencies to extravagance in the expenditure of money, which have been so flagrantly displayed in public affairs, have been brought under control, it is hardly to be expected that private business will develop the urge, or the will to do, which must be the precursor of effective action.

Perhaps a beginning might be made by inducing some of the independent agencies of research to survey the field and, in particular, to gather concrete information as to the cost to the tax-payer of the clerical activities that have been instituted as an apparently minor phase in the administration of the various governmental organizations which have been established at the Federal capital. My own observations lead me to conclude that if present developments along these lines are continued on a permanent basis, the time will ultimately arrive when many of these organizations will be threatened with the danger of stifling in a morass of paper work.

As for the factor of space, not alone is it impossible under present conditions in Washington to find housing facilities, however inferior, in which to accommodate clerical activities incident to the administration of such undertakings as the Social Security Board, but what is quite as much to the point is the fact that governmental buildings recently erected leave much to be desired when the need for intelligent planning and arrangement of clerical staffs and equipment is taken into account.

Following an inspection made a short time ago of one of these buildings, I was asked to appraise it from the planning point of view. My answer, made with what was interpreted by my interrogators as brutal frankness, was that those responsible for the planning of the building had succeeded brilliantly in providing everything but adequate and well-arranged space.

I revert, finally, to the all-pervading influence of science. Its status in business today constitutes a challenge to every forward-looking executive, whether his interests be in the office or the plant, in production, sales or finance, to gauge his own mental processes and ability to understand and apply the scientific method to his daily activities. In what spirit shall this challenge be met? The answer to this query, it seems to me, can be given in no more effective manner than by relating in a few words the story of Dr. William Beaumont, whose name and fame are enshrined forever in the annals of medicine.

A little over a hundred years ago, Beaumont was a young and obscure army surgeon, stationed at the military barracks at Ft. Plattsburg, New York. One day there was brought to him for treatment a French Canadian woodsman, St. Martin by name, who had been horribly torn in the abdominal region by the accidental discharge of his gun. After applying heroic measures and devoting unremitting care to the injured man, Beaumont managed to save his life. But even his great skill was unequal to the task of closing the hole in the abdominal wall occasioned by the penetration of the shot. Thus it was vouchsafed to Beaumont, first among all men since the very dawn of life upon earth, to observe through the opening provided, the activities of the vital organs of a living human being.

In the skilled surgeon there at once developed the determination (fortified no doubt by a long held passion for research, joined to eager intellectual curiosity) to make the most of the unparalleled opportunity so miraculously presented to him. Securing the consent of St. Martin to share his modest quarters with him and to submit to experiments which he proposed personally to undertake, Beaumont during the course of the next two or three years actually performed over one hundred experiments to determine the conditions controlling the processes of digestion. St. Martin, being fed up in more ways than one with these intimate interferences with his physical integrity, ran away, but was induced by the promise of a bounty to return and to submit himself to further experimentation.

What Beaumont learned as the result of his tests and observations constituted an astounding and epoch making contribution to the advancement of the medical knowledge of the day. In fact, many of the beliefs then held by scientific men were completely overturned and much of what is now accepted fact is derived from the discoveries then made by Beaumont.

By nature cautious and of great modesty, as well as imbued with a thorough appreciation of ethical procedure, Beaumont reduced his findings to written form and, under the title, "Experiments and Observations of the Gastric Juice and Physiology of Digestion," submitted them to his medical society in Boston for review and critical comment. Because of the revolutionary character of his findings, he found it expedient to write a preface to the report; in this a sentence occurs which will for all time be an inspiration and an example to conscientious devotees of research. This is what he wrote: "I submit a body of facts which cannot be invalidated. My opinions may be doubted, denied, or approved, according as they conflict or agree with the opinions of each individual who may read them; but their worth will be best determined by the foundation on which they rest—the incontrovertible facts."[10]

Thus did a great scientist take his stand and nail his colours to the mast!

[10] Beaumont, William, M.D., Experiments and Observations of the Gastric Juice and Physiology of Digestion. Reprinted by Harvard University Press, Cambridge, 1929.

# Preservative Treatment of Structural Timbers

## with Special Reference to Creosoting

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SUMMARY.—**Discusses the principal causes of decay in wood and the methods of treatment designed to prevent the action of these agencies or to render wood fire-resistant. Methods of testing preservatives, the preparation of timber for treatment, and the application of preservatives to Canadian timber products are described.**

In order that forests should not become choked with fallen trees, nature provided various destructive agents to clear away the timber lying on the ground, and these destructive agents sometimes interfere with the use man desires to make of wood when the conditions of service are similar to the damp ground of the forest. When conditions of service are changed by maintaining the timber in a dry, or water-soaked condition, wood-destroying fungi and most insects do not flourish, and, therefore, maintaining wood in an air-dry condition is the simplest form of wood preservation. Although wood submerged in fresh water will remain sound indefinitely, sea water is sometimes infested with "marine borers" which will rapidly destroy it. Wood in service is also, of course, subject to destruction by weathering, fire, and mechanical wear

### Decay

The decay of wood is due to the growth in the wood of low forms of plant life known as fungi. Fungi will grow readily in untreated wood provided the conditions of moisture, air supply, temperature, and food are suitable. The food is supplied by the wood substance, and it is only necessary for conditions of moisture, air supply and temperature to be favourable to bring about the decay of timber in service. The moisture conditions required for growth vary over a wide range. Wood which is maintained below a moisture content of from 20 to 25 per cent will not be attacked by fungi owing to insufficient moisture, and wood which is stored under water will not be attacked, owing to the cells of the wood being so filled with water that the air supply is insufficient. When timber is buried in the ground the air supply varies with the nature of the soil. In heavy clay soils the air supply is diminished at a short distance beneath the surface, while in light sandy soils decay can progress up to a depth of four to five feet below the surface. The upper and lower temperature limits for fungus growth are about 110 and 32 deg. F. respectively, and the best temperature is between 65 and 95 deg. F.

Since the above requirements for the growth of fungi are found in the living tree, it is not surprising that there is a considerable loss of merchantable timber due to decay in standing trees. The question as to whether decay in standing trees will continue after the timber is cut is of considerable importance. Tests carried out at the Forest Products Laboratories, Dominion Forest Service, Department of Mines and Resources, indicate that the fungus, *Trametes pini*, which causes the red heart rot in jack pine, does not appreciably affect the life of railway ties, provided the attack is confined to small pockets of incipient decay so located that the strength of the tie is not reduced.

During the air-seasoning of green lumber, what are known as staining fungi are sometimes very troublesome, and cause a considerable loss owing to degrade of the lumber. An example is blue-stain in the sapwood of white pine. The strength of the wood is usually not reduced by the staining fungi, which feed on the food stored in the wood cells and seldom attack the cell walls. The discolouration of the wood is caused by the coloured mycelium of the fungi, and is sometimes augmented by infiltration into the cell walls of the wood of substances produced by the fungi during growth.

The terms "wet rot" and "dry rot" are sometimes rather loosely used. Wet rot might be considered to describe the large group of fungi which bring about the decay of ordinary timbers such as fence posts, telephone poles, railway ties, and similar products. Dry rot can be used to describe a limited group of fungi, one of which is known as *Merulius lachrymans*. These fungi possess the property of conducting water through their mycelia. When the decay starts in a wet spot the mycelia can spread over brick or stone work and, on reaching dry wood, can destroy it although the timber was too dry for decay to start at that point.

The service life of untreated timber is largely governed by the fact that optimum conditions of temperature, moisture, and air supply seldom occur. When all these three conditions are at the optimum point, the decay of wood is very rapid. Obviously, little or nothing can be done to control the temperature, or air supply, but a great deal can be done to insure that the moisture content of the timber is below that favourable to fungus growth, that is to say below 20-25 per cent.

The toadstools that appear on the surface of wood which is in an advanced stage of decay, are a convenient point at which to start a description of the life cycle of a fungus. These toadstools are known as fruiting bodies, and at maturity shed minute seeds or spores. Each tiny spore that settles on wood, where conditions are favourable to decay, can germinate and start the formation of tiny cells, which possess the property of releasing secretions, or enzymes, that break down the wood structure and reduce it to a soluble form. A plant cell consists of an outer wall, within which is a layer of living protoplasm, which appears to function as a semi-permeable membrane, and within the semi-permeable membrane are the cell sap and other substances. By "semi-permeable" is meant that certain substances in solution may pass through the membrane while others cannot. In wood-destroying fungi, the cells absorb the wood substance brought into solution by the secretions released by the cells, and this food promotes growth, and the formation of new cells, which multiply in the form of slender filaments or hyphae, which spread like the branches of the tree, and then form a mass known as mycelia in the broken down and disintegrated wood. The mycelia eventually form fruiting bodies on the surface of the timber, and the life cycle is thus repeated. Decay can also spread by the growth of mycelia from decayed timber into adjacent sound timbers.

In order to protect timber from decay it may be impregnated with chemicals which poison the wood substance on which the fungi grow. It is now known that wood preservatives must be toxic to, or at least inhibit, the growth of fungi, but it is interesting to note that the preservatives most commonly used in Canada and the United States, creosote and zinc chloride, were in use in England as early as 1838, while it was not until 1874 that it was shown by Hartig that the decay of wood is caused by fungi, and is not, as previously believed, a case of slow combustion.

It is a well established fact that the presence of a sufficient quantity of creosote, or of some water-soluble salts such as zinc chloride or sodium fluoride, will prevent the growth and cause the death of wood-destroying fungi. If it were only the water-soluble salts which were toxic it would be possible to explain the action by saying that the salts in solution could pass through the semi-permeable membrane of the cells and interfere with the life processes of the fungus. However, since creosote oil is also very toxic, it is necessary to find some other explanation. E. Bateman of the Forest Products Laboratory, Madison, Wisconsin, U.S.A., has advanced an interesting theory that creosote may be considered as consisting of two groups of compounds, one of which is sufficiently soluble in water to produce a toxic solution, which, being water soluble, can be absorbed by the body organisms of the fungus. The non-toxic group of compounds in the creosote act as a reservoir, in which the toxic oils are completely soluble, as well as being slightly soluble in water. A state of partial solubility of the toxic oils then exists between the non-toxic oils and the adjacent moisture in the wood. As the moisture in the wood changes, fresh toxic solution is drawn from the creosote. Since creosote has been known to protect timber from decay for periods of forty years and over, it is evident that the withdrawal of the toxic solution from the creosote, as outlined above, is very gradual.

### Insects

Very fortunately timber in service in Canada is comparatively free from destruction by insects. Unpeeled logs left on the ground in the bush will be degraded by the action of insects, but attacks on fence posts, poles or structural timbers are so infrequent that there is little or no demand in Canada for lumber treated to resist insect attack. In other countries, where termites are prevalent, it is necessary to provide adequate measures of protection. Fortunately, the chemicals used to protect timber from decay will usually provide protection from insect attack.

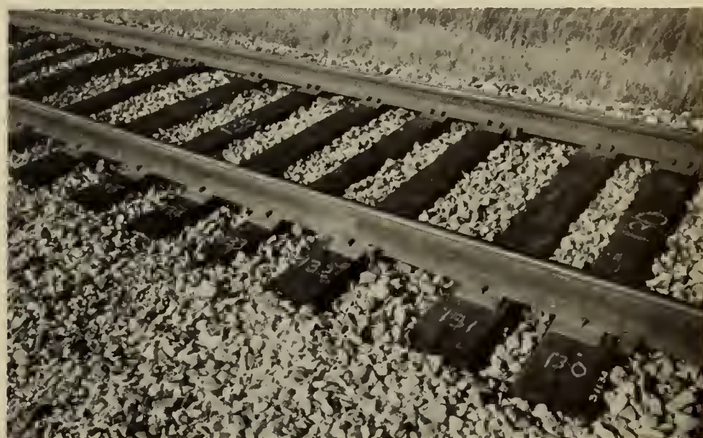

**Fig. 1—Creosoted jack pine ties, incised and not incised, after 14 years' service in main line.**

### Marine Borers

Wood, submerged in fresh water, will last indefinitely, but sea water, in many parts of the world, including the Atlantic and Pacific Coasts of Canada, is infested with marine borers, which burrow in the wood for shelter and food and eventually totally destroy it. Marine borers may be divided into two classes, the *Mollusca* commonly known as "Teredo" or "ship-worms," and the *Crustacea* which are known as "Limnoria" or "wood lice." Teredo attack starts from a small embryo floating in the water, which attaches itself to the wood and bores a minute hole. When once the teredo penetrates beneath the surface, the hole is extended and enlarged to accommodate the rapidly growing body, and eventually the timber is honeycombed with longitudinal galleries or burrows, usually, in Canadian waters, 6 to 12 inches in length, and about ¼ of an inch in diameter. The original entrance hole is not enlarged, so that what is in appearance a sound pile, may be nothing but a weakened, honeycombed shell. The attack of limnoria is quite different from that of teredo, inasmuch as the timber is eaten away on the surface, and the damage is apparent to the eye. Limnoria are about the size of a grain of rice, and excavate little galleries, side by side, extending about half an inch below the surface. The burrows are so numerous, and so close together, that the partitions of wood between the tunnels are soon worn away by the action of the waves, whereupon the limnoria make fresh burrows, which are in turn disintegrated. The piling attacked is consequently eaten away until it resembles an hour glass.

### Weathering

When unpainted wood is exposed to the weather the moisture content of the outer fibres fluctuates with changes in atmospheric conditions. The repeated swelling and shrinking, caused by the changes in moisture content, gradually loosens the outer fibres, and the wood acquires the well-known weathered appearance. Weathering can be prevented by paint specially prepared for use on exterior woodwork.

### Fire-Retardant Treatment of Wood

Wood can be impregnated with certain chemicals which render it comparatively inert to fire, that is to say, if a piece of the treated wood is placed in a fire it will slowly char, since it is an organic material, but if it is removed from the fire, or if the surrounding fire dies out, the wood will not continue to burn. Some of the most effective fire-retardant chemicals are phosphoric acid, ammonium phosphate, ammonium borate, ammonium sulphate, ammonium chloride, magnesium chloride, zinc chloride, boric acid, and borax. Mixtures of these and a few other chemicals form the base of most of the fire-retardant treatments which are used. On the whole, ammonium phosphate and ammonium sulphate are probably the most important commercial fire-retardant chemicals. Ammonium phosphate is by far the most effective, but costs two to three times as much as ammonium sulphate. An effective fire-retardant treatment is a mixture of ammonium phosphate and ammonium sulphate. The proportions can be varied from 70/30 to 30/70 without any very noticeable difference in the fire-retardant effect. The ammonium sulphate is hygroscopic and the limiting factor in the percentage that can be used, and consequently the cost of the treatment, is the humidity to which the treated wood is exposed in service. It is advisable to add a small percentage of a toxic salt to control moulds and wood-destroying fungi. Two to three per cent of boric acid is sometimes used.

**Fig. 2—Creosoted hardwood culvert.**

At present wood treated with fire-retardant chemicals is not produced commercially in Canada. This is easily explained by the high cost of fire-retardant treated wood as marketed in New York where the building by-laws call for the fire-retardant treatment of all wood used in buildings over 150 ft. in height. The prices range from $50 to $75 per M., in addition to the original cost of the wood. This is for timber which has been treated to refusal, under pressure, with water solutions of fire-retardant chemicals. At first thought the price may seem excessive, but when it is remembered that the timber must be air-dried before treatment, then treated in a cylinder under pressure, and again dried after treatment, it will be found that an estimated cost in Canada of $40 per M. is not unreasonable. In order to reduce the high cost of fire-retardant treated wood, it will be advisable to try to determine just what degree of fire-resistance should be imparted to wood in order that it will survive the fire hazards found in service. Under present standards, it is necessary to impregnate timber with from 4 to 5 lb. of chemicals per cu. ft. of wood. It is known that larger timbers are very fire-resistant. This has been demonstrated in many fires, and is recognized in the design of what is known as the slow-burning type of mill construction. Certainly this would seem to indicate that it should not be difficult to add a high degree of fire-resistance to larger sizes of timbers with less expensive treatments. Compared to other available construction materials, wood compares favourably when the following factors are taken into consideration:

(1) Ease of ignition or inflammability.
(2) Rate or intensity of burning, which is largely a question of the air supply, and this can be reduced by the use of fire-stops.
(3) Resistance to change of shape on heating.
(4) Conductivity.
(5) The effect of water applied to hot members during a fire.

After considering all the above factors, it would seem reasonable to suppose that present laboratory tests, which indicate the necessity of using 4 to 5 lb. of chemical per cu. ft. of wood, should be much more closely co-ordinated with actual service requirements. Until this is done, there is a danger of penalizing wood by insisting on heavy and expensive treatments, whereas for many uses, lighter treatments may be all that is actually required, and, in some types of construction, untreated wood is sufficiently resistant to fire to provide all the protection that is necessary.

### Preservatives

Preservatives in general use may be divided into two classes:

(1) Oils such as creosote or mixtures of creosote and coal tar, creosote and crude oil. (Crude oil is not a preservative.)
(2) Water-soluble salts such as zinc chloride.

### Creosote

The wood preserving industry has little or no control over the production of creosote, which is a by-product from the distillation of coal tar, and the tar is a by-product from the distillation of coal, for the purpose of obtaining illuminating gas or metallurgical coke. This situation has existed for nearly a century, and it will be readily understood that during this period many different grades of creosote have been used for the preservation of timber, owing to the many types of coal used, and continual changes and improvements in the methods of distilling coal and tar. Owing to the complex and varying constituents of creosote, it is difficult to determine which are the essential fractions, since up to date so many types of creosote have provided adequate protection from decay when properly used. If there had been failures in service, due to the creosote alone, the problem would be easier to solve. Although no definite results have been obtained, a great deal of work has been done in Europe and the United States in the endeavour to determine which fractions of creosote protect timber for long periods of service from decay, marine borers, and insects.

The specifications for creosote for use as a wood preservative require that certain physical tests be complied with in order to insure that a pure coal-tar product is supplied. The specifications such as those issued by the American Wood Preservers' Association, the American Railway Engineering Association, and the Bureau of Standards, U.S.A., are a commercial compromise. On the one hand are consumers asking for types of creosote that they have successfully used for many years, and on the other hand are the producers of creosote forced to market the type of creosote that developments in distillation processes make available. As long as only limited quantities of new types of tar or creosote are produced, some distillation plants can blend different types of tar or creosote to produce a creosote to meet the specifications. When the quantity produced by the new method becomes larger, it is necessary to amend the specifications.

The first retorts for distilling coal for the production of illuminating gas were of cast iron, and operated at temperatures of about 800 deg. C. In order to increase the yield of gas, horizontal retorts lined with fire clay, so that the temperature could be raised to 1300 deg. C., were developed. Up to this point the retort was charged intermittently, and the next development was the vertical retort which could be operated continuously. The wish to recover by-products in the manufacture of metallurgical coke led to the development of the by-product coke oven. All the above methods for distilling coal affect the type of tar produced, and the type of tar produced is also dependent on the type of coal used. Cast iron retorts operated at low temperatures produce a tar rich in tar acids and comparatively low in naphthalene. Horizontal retorts, operating at higher temperatures, increase the naphthalene content and also the free carbon. Vertical retorts produce a tar higher in tar acids and lower in naphthalene than the horizontal retorts. Coke oven tars are intermediate between vertical retort tars and horizontal retort tars. Water-gas tar is of a different character. It is not a coal tar product inasmuch as the raw materials are coke and petroleum oil. A large body of coke is placed in a retort and heated to incandescence by an air blast. The air blast is shut off and steam then blown through the coke. The steam is decomposed and reacts with the carbon with the resulting production of carbon monoxide

Fig. 3—Highway overhead crossing at Haig, B.C. Composite concrete creosoted timber deck on creosoted timber bents.

and hydrogen. The water gas thus produced does not meet most standards for city gas, and has to be enriched by carburetting, that is by spraying petroleum oil into the gas in chambers containing hot refractory brick-work. The high temperature volatilizes the oil and fixes it as a gas. Some heavy vapours formed in oil carburetting are not permanent gases, but condense out of the gas on cooling. The liquid so condensed is known as water-gas tar. There is some doubt as to whether or not creosote, distilled from water-gas tar, is as effective as pure coal-tar creosote as a wood preservative, although it is quite certain that it has a marked protective value.

In the distillation of tar the market for pitch is often the controlling factor, and the distillation is cut to produce, as for instance in the early days in America, a soft roofing pitch and, consequently, a light, low-boiling creosote, while in Europe, a hard briquetting pitch was in demand, and resulted in the production of a heavier creosote. In the early days, the wood preserving industry in the United States was trying to obtain a heavier creosote than was generally produced in that country, but was forced to include in its specifications Grades 2 and 3 creosote, in order to admit the use of available creosote with 35 and 40 per cent distilling up to 235 deg. C. The industry urged tar distillers to increase the supply of heavier domestic creosote. This was done by developing the markets for harder pitches and the manufacture of pitch coke, thus permitting the distillation to be carried further and increasing the production of higher-boiling oils. The more general production of heavier creosote has now permitted the elimination of Grades 2 and 3 from the specifications. For the distillation of tar and starting with the simple batch still, steam agitated stills, vacuum stills, gas recirculation stills, pipe stills, coke stills, and later coke oven stills have been developed, and the percentage of creosote recovered raised from about 40 per cent in the batch still to about 70 per cent in the coke-oven still.

The situation today is that the producers of creosote are now marketing considerable quantities of what is known as high residue creosote oil. In a sense they have gone beyond the demand of the wood preservation industry. A typical so-called high residue creosote is one of which 60 per cent is distilled below 355 deg. C. and the remaining 40 per cent is called the residue. In the period between 1914 and 1929 the percentage of creosote and creosote coal-tar solution produced and used in the United States, and having a residue of less than 20 per cent, fell from 27 to 5 per cent. The question that is troubling many people at the moment is whether the lighter but more toxic oils, such as have been used in the past, should be regarded as being the most efficient, or whether the heavier, high residue oils, which contain less of the low-boiling fractions, are the suitable types. The fraction of creosote distilling below 270 deg. C. is more toxic and also more volatile than the remainder. There is a conflict between toxicity tests, which emphasize the advisability of using a considerable percentage of creosote distilling below 270 deg. C., and reports on the analysis of creosote extracted from timber after various periods of service, which show that the creosote distilling below 270 deg. C. has largely disappeared. However, just because the lower fractions have disappeared in service is not to say that these lower fractions have not played a part in protecting the timber, and it is not possible to say definitely that creosote, similar to that extracted from timber after a long period of service, would protect timber for as long a period as the original mixture of high and low boiling oils. Fortunately, it is possible to use an additional 2 to 3 lb. of creosote per cu. ft. of wood when there is any question as to the length of life that will be obtained from any coal-tar creosote.

The amount of creosote required to protect wood varies with the species and with the conditions of service. In general, it will usually be more economical in the end to use the maximum amount of creosote specified instead of the minimum. For marine piling, complete saturation of the sapwood rings is required, and in species having a sapwood ring of 3 to 3½ in., an absorption of 16 to 18 lb. of creosote per cu. ft. of wood will be necessary, while for other species with 1 to 1½ in. of sapwood, 14 to 16 lb. will be sufficient. For structural timbers of approximately 6 by 8 in. in cross section, 6 to 8 lb. per cu. ft. for empty cell treatment, and 8 to 10 for full cell-treatment will be suitable. For larger and smaller timbers, the absorption should be decreased and increased respectively in order to compensate for the change in ratio of surface area to volume.

### Zinc Chloride

Zinc chloride is a water-soluble salt, and for the treatment of timber is used in water solutions up to 5 per cent in strength. From ½ to ¾ lb. of dry salt per cu. ft. should be used to protect timber from decay.

Mercuric chloride, copper suphate, and sodium fluoride are also water-soluble salts and are used in much the same manner as zinc chloride. They are, however, with the exception of sodium fluoride, corrosive to metals, so cannot be used in the ordinary steel treating cylinders in use at commercial treating plants.

### Testing of Preservatives

Unfortunately, a reliable estimate of the service life of a preservative cannot be based on data obtained solely from accelerated laboratory tests. However, although the conclusions to be drawn from laboratory tests are very often a matter of individual opinion, and there is no guarantee that the conclusions will be confirmed by service tests, it is still possible to obtain a fair idea as to whether a new preservative is worthy of serious consideration. In the first place, the preservative must be cheap. Secondly, it must be toxic to, or at least inhibit, the growth of fungi. Thirdly, the question of permanency must be considered, and the less volatile and the more resistant to leaching by water the better. The fact that preservatives may be exposed to water that is slightly acid, or slightly alkaline, must also be considered. Information on these points can be obtained by laboratory tests, and it is thus possible to limit service tests, which will require anywhere from ten to twenty years, to compounds that show satisfactory results in preliminary laboratory tests.

The toxicity of a preservative, as determined in a laboratory, is often quoted, and while it is essential that a preservative be toxic, the extent of the experimental error in toxicity determinations is not always realized, and undue weight is sometimes given to small differences in toxicity. Also, it should be remembered that toxicity tests give little or no information regarding permanency, or the length of time the portion of the preservative remaining in the treated timber will be toxic.

In order to study the different types of fungi, pathologists developed a technique of growing fungi on an artificial food or media placed in glass containers. One of the mixtures on which fungi will grow readily is made up of malt extract, agar agar and water. A small piece of decayed wood, which need only be 1/8 in. or so in thickness, and long enough to be held in forceps, is placed in the media in the glass container, and the fungus will spread from the decayed wood into the media. Of course, there is often more than one fungus present in the decayed wood, and also moulds and bacteria may be present. However, by transferring selected pieces of the media containing the desired fungus, it is possible to obtain a pure culture. This strain of the fungus, as it is called, can be maintained for years by subsequent transferring to fresh flasks.

For toxicity tests it was, therefore, quite simple to go one step further and add different percentages by weight of a preservative to the media placed in a set of glass flasks. When the flasks were inoculated with the same strain of fungus, growth was not prevented by the low concentration of preservative, but higher percentages killed the inoculum. The toxicity was taken as the percentage between the flasks showing growth and no growth. In order to obtain the same figures for the toxicity of a preservative, different workers must use the same strain of the same fungus, similar media, and store the flasks in boxes maintained at the same temperature and humidity. The use of different fungi and different strains of the same fungus will change the percentage of preservative required, so that the toxicity may be 0.05 for one fungus and 0.10 for another. In a very toxic fraction of low-boiling creosote only one or two drops mixed with the medium are required to bring the percentage of the preservative by weight up to the killing point.

Toxicity tests can also be carried out by growing mats of fungus on agar agar, and then placing small blocks of wood approximately ½ by ⅝ by 2 in., treated with different concentrations of preservative, in a set of flasks. The toxic concentration, as determined by the wood block test, usually differs considerably from tests on artificial media. The difficulty with the wood block test is that it is not possible to control the moisture content of the wood in the flasks, and obtaining the optimum moisture content for fungus growth is more or less a case of hit or miss. Wood block tests require from six to eight months' exposure.

It will be noted that toxicity tests, as outlined above, are simply empirical tests. A true understanding of the action of preservatives will involve a proper conception of the life processes of fungi as mentioned under the heading "Decay."

Laboratory tests to determine the permanency, or resistance to evaporation and leaching, of preservatives are not as standardized as toxicity tests. Obviously, a large number of tests can be developed in which small wooden blocks, treated with a preservative, can be passed through cycles of heating and cooling in air, and leaching in hot or cold water. A comparison of the properties of different preservatives under the conditions of the test can be obtained, and by including preservatives that have been used extensively in the past, such as creosote and zinc-chloride, some information can be obtained regarding the possibilities of a proposed preservative, and those that cannot pass a few simple comparative tests can be eliminated and extravagant claims regarding proposed wood preservatives can be checked.

As a rule, laboratory tests can easily be made too drastic, but this has the advantage that the error is on the side of safety, if the tests are carefully carried out. When reliable preservatives are available, it is not necessary to take chances on untried or questionable methods of treatment.

As mentioned before, service records are the final test of a preservative. However, to be of value, service tests require details of the preservative used and the method of treatment, and reports on yearly inspections, so that all renewals for decay, mechanical wear or other causes can be taken into consideration when calculating the average life. This continuity of interest over a period of years is seldom obtained, and it is not surprising, therefore, that the number of completed service tests which fulfil these requirements is surprisingly limited. There are an embarrassing number of half recorded service test results which fully demonstrate the value of preservative treatments, but cannot be used to determine the results of minor differences in preservatives, or improvements in processing, owing to lack of details. Of recent years much more attention has been paid to the proper recording of service tests, and the detailed information collected will in time provide a much closer co-ordination between service tests and laboratory tests, so that eventually it should be possible to develop laboratory tests to a point where service tests will not be as essential as at present.

### Preparation of Timber for Treatment

Careful preparation of timber for treatment is necessary, in order to obtain an adequate penetration of the preservative to a depth of one-half to one inch, and to ensure that the timber does not check after treatment, and expose untreated wood to the action of fungi. The preferred method is to air-season the timber before treatment and, by removing the free water, provide space for the penetration of the preservative and, if checking cannot be prevented, it is preferable that it should occur before and not after treatment. In the early days of the wood preserving industry, indiscriminate treatment of different species of green timber resulted in short life, due to checking after treatment, and led to emphatic statements regarding the necessity of only treating thoroughly air-seasoned timber. However, in order to benefit by the advantages of air-seasoning, consumers have to foresee their requirements sufficiently in advance to allow time for the timber to air-season before treatment. Also, in order to air-season large quantities of timber at a reasonable cost, it is necessary to purchase land for seasoning yards at a reasonable price, and climatic conditions have to be such that the timber can be air-seasoned with little or no loss from decay. In the Southern States decay during seasoning was a problem, due to climatic conditions, and led to the extensive use of conditioning green southern yellow pine by steaming in the treating cylinder followed by a vacuum. On the Pacific Coast of Canada and the United States, possibly due to the necessity of locating treating plants on more expensive water front property, with rail and dock facilities, the treatment of green timber was favoured, and as steaming was not effective in the case of Douglas fir, the Boulton process of conditioning by boiling timber in oil under a vacuum was adopted. In Canada, with the exception of Douglas fir, little or no timber is treated in the green condition. The Laboratories have carried out experimental treatments on green yellow birch, hard maple, and beech ties, and on green jack pine and red pine poles in order to obtain information on the penetration of creosote and the checking of the timber during and after treatment. The only indication of success has been in the case of green yellow birch ties, where a good penetration was secured and the checking after treatment was much less than in the case of hard maple and beech. Jack pine and red pine poles, creosoted after preliminary steaming and vacuum in the cylinder, showed poor results. The penetration of creosote was poor, and there was a considerable amount of checking in the heartwood, extending along the length of the pole. The steam seasoning of red pine and jack pine structural timbers should present less difficulty, but in the case of the heartwood of the pines, the lower the moisture content the better the penetration of creosote.

Fig. 4—Untreated drift timbers in a mine.

In Canada, softwoods require from five to twelve months and hardwoods from five to six months seasoning depending on climatic conditions and the season of the year.

### Cutting and Framing Before Treatment

Since the penetration of preservatives into wood is not complete, it is necessary to depend on the maintenance of an exterior treated shell of from one-half to one inch in depth. In order to secure this it is essential that all cutting and framing should be carried out before treatment. There has been a remarkable development in recent years in pre-framing bridge and other construction timbers at the treating plants before treatment. It has been found that quite intricate timber structures can be shaped and fitted, and erected in the field after treatment, with little or no disturbance of the exterior treated shell.

### Incising

The incising process consists of passing the timber through a series of studded rolls which punch incisions spaced 6 in. apart longitudinally and staggered one-quarter inch in the faces of the timber. The penetration of preservative is greater longitudinally than radially, and a uniform penetration to the depth of the incisions is obtained. This process is extensively used in Canada, and nearly all the large commercial pressure-treating plants are equipped with incising machines.

### Treating Processes and Equipment

The object of all treating processes is to apply the selected preservative in such a manner that the increase in service life will pay for the cost of treatment and also return a dividend or profit on the money invested in the treatment. The selection of the preservative to be used and the decision as to how it should be applied are governed by the conditions of service and the facilities available for carrying out the treatment. There are several methods of applying preservatives, some of which are undoubtedly superior to others, but each method possesses certain advantages which render it suitable for use under particular conditions. The different methods may be grouped into two divisions, namely, superficial and pressure treatments. Superficial treatments cover only the surface of the wood with the preservative and are not as reliable as pressure treatments, where the preservative is forced beneath the surface to a depth of one-half inch or more. Superficial treatments are cheaper than pressure treatments and a minimum of equipment is required, so that their use is justified under conditions where a short period of service life is required or where transportation costs prohibit the use of timber treated by a pressure process. Descriptions of the various methods of treatment follow.

### Brush Treatment

This is a superficial treatment with a creosote oil preservative. As the name implies, the process consists of applying the oil to the surface of the wood with a brush. The wood to be treated should be well air-seasoned and its surface should be perfectly dry. The oil should be heated to about 190 deg. F. before being applied, and care should be taken to brush the preservative thoroughly into all checks, cracks, and joints. For best results, a second treatment after an interval of several hours is recommended. This method of treating wood is cheap and requires no outlay for apparatus or any skill in its application. But the protection against decay afforded by the creosote does not extend beyond the surface of the wood, and this surface, therefore, should not be broken through or worn away and expose the untreated interior. Should any such exposure occur, either through checking of the wood or from mechanical abrasion, the fresh surfaces should again be well brushed with hot creosote. Of course, if the timber is even slightly infected with decay, a surface coating is useless. Thus a brush treatment on timbers containing sapwood, which is very susceptible to decay, will, as a rule, be less effective than a brush treatment applied to timbers that are 100 per cent heartwood. In general, a brush treatment may not be expected to afford protection against decay for more than a few years. It has, therefore, limitations, although in some instances the life of timber so treated may be extended by a yearly or semi-yearly brush treating of the wood in place, with a creosote oil.

### Dipping

This is also a superficial treatment consisting of dipping or submerging the wood for a short period in a creosote oil. As in the brush treatment, the wood should be dry and well seasoned, and the temperature of the oil should be maintained at about 190 deg. F. during the treatment. This process requires a container or vat large enough to permit submersion of the wood and also a means for heating the oil in the container. For these reasons the method is not always suitable for the treatment of small lots of timber. For large quantities of timber, however, it is more economical than a brush treatment, since dipping can be carried out much more quickly than brushing. Further, owing to the greater certainty of the preservative flowing into checks and cracks during the submersion of the wood, the dipping treatment is safer and in general gives better results than brush treatments in prolonging the life of the timber. Any checks or abrasions that may occur during or after the placing of the treated wood in service should be well brushed with hot creosote.

### Open Tank Treatment

This method of treatment derives its name from the character of the equipment required, namely, two open tanks of any convenient size and shape. It is used chiefly for the butt treatment of cedar telephone poles and for the butt or full length treatment of fence posts.

**Fig. 5—Incised timber and chisel point knife.**

The poles or posts are placed upright in the creosote to a depth of 6 to 12 in. above the ground-line and allowed to stand for from one to several hours, during which time the temperature of the creosote is maintained at about 220 deg. F.* This hot bath partly volatilizes the moisture in the wood and expands and forces out of the wood-cells a certain amount of air and moisture. The posts are then removed from the hot tank and quickly submerged in a tank of cold oil. This cools and contracts the air and moisture in the wood and draws in the creosote. Instead of using a separate cold tank the posts may be kept in the hot tank, which is allowed to cool. The duration of the hot and cold baths depends on the species of timber and the dimensions of the posts under treatment. The air-seasoned sapwood of some species of timber, such as red pine, will readily absorb creosote during the cold bath, and more difficulty will be experienced in preventing excessive consumption of creosote than in obtaining complete penetration of the sapwood. With the exception of spruce, hemlock, and a few other species, sufficient penetration of creosote in the sapwood can be obtained, in round posts, to increase the average service life from five years untreated to twenty years treated.

*It is advisable to use a creosote in which the distillate does not exceed 25 per cent up to 235 deg. C.

Open tank treatments can also be used for the treatment of round posts or poles with water-soluble preservatives, such as zinc chloride or sodium fluoride.

Open tank treatments have not been extensively used for the treatment of heartwood timbers, since the heartwood is much more refractory, in nearly all species, than the sapwood.

### Full-Cell Process

This method of treatment is a pressure process often referred to as the "Bethell" process, after John Bethell, who patented it in England in 1838. Either green or seasoned material may be treated by this process, although best practice recommends that the wood be well air-seasoned before treatment. The timber is loaded on to small steel cars, or "buggies," which are then run into a long horizontal steel cylinder. This cylinder or retort is equipped with steam coils for heating the preservative, and has a cast-steel door fitted to a cast-steel flange, which is riveted to the shell of the retort. The retort varies from 6 to 8 ft. in diameter and from 80 to 150 ft. in length. After the retort door is closed and bolted, the timber, if green, is subjected to a bath of live steam—usually not exceeding 20 lb. per sq. in.—for several hours. With air-seasoned material the steam bath is omitted. A vacuum is then drawn on the cylinder by means of a vacuum pump and maintained for one or more hours. Without breaking the vacuum the preservative, which has already been heated by steam coils in the working tank, is drawn or pumped into the cylinder until the latter is full. Pressure is then built up and maintained in the cylinder by means of a pressure pump which forces the preservative from the working-tank into the cylinder. The pressure used varies between 100 and 180 lb. per sq. in., and is maintained until the gauges or scales show that a pre-determined amount of preservative has been forced into the wood, or until the wood has been treated to refusal. During this pressure period the temperature of the preservative in the cylinder is maintained at approximately 190 deg. F. The pressure is then released and the oil is pumped from the cylinder back to the working tank. The charge of timber is then allowed to drip for a short period (many operators apply a final vacuum to hasten the drip and dry the timber) after which it is removed from the cylinder.

The full-cell process may be used to treat timber with creosote or with mixtures of creosote and other oils, or with solutions of water-soluble preservatives. If the treatment is carried out with the water-soluble salt, zinc chloride, the process is known as the Burnett process, from a patent granted to William Burnett in England in 1838 for the preservation of timber with zinc chloride. The full-cell process has proved to be very effective in prolonging the life of timbers used for different purposes. With creosote oil, however, the process is relatively expensive, owing to the amount of oil that is absorbed by the timbers. For the protection of timbers against marine borers this heavy absorption is both desirable and necessary, but for other purposes a diminution of the amount of creosote retained by the timbers would still give satisfactory results, although there is a relation between the amount of creosote absorbed and the life obtained in service. A reduction in the amount of creosote used may be secured by empty-cell treatments, which are described below.

**Fig. 6—Teredo attack on untreated pile, Iona, C.B.**

LOWRY PROCESS

This process is named after C. B. Lowry, to whom was granted in 1906 a United States patent covering the process. This is also a pressure process and it differs from the full-cell process in the order of application of pressure and vacuum. Air-seasoned timber is loaded on trams or buggies and run into the treating cylinder, which is then closed and filled with hot oil from the working tank. A pressure of from 100 to 180 lb. per sq. in. is applied and maintained until a certain absorption of preservative by the wood is secured. During this pressure period the oil in the cylinder is maintained at a temperature of about 190 deg. F. After the pressure is released the oil is pumped back to the working tank and a vacuum of 24 to 26 in. of mercury is then drawn on the cylinder by a vacuum pump. After the vacuum is broken, the recovered oil is pumped back to the working tank, the cylinder door is opened, and the charge of timber removed. The Lowry process, which recovers some of the free oil from the wood-cells, thus leaves the cells to some extent empty of creosote and is, therefore, often described as an empty-cell process. The process is extensively used for the treatment of railway ties, and the ratio of oil absorbed to the depth of penetration is smaller than in the Bethell full-cell process.

RUEPING PROCESS

This is also a pressure process used for the treatment of timber. It was developed in Germany and patented in the United States in 1902. The object of this process is to obtain a deep penetration of creosote oil in timber, and then to withdraw a percentage of this oil before the timber is removed from the cylinder. Therefore, it is essentially an empty-cell process. The timber to be treated should, preferably, be air-seasoned, though green timber may be treated after it has been subjected to a steaming-and-vacuum conditioning in the cylinder, or has been seasoned by boiling-under-vacuum in oil in the cylinder. The pressure of the air in the cylinder is raised to about 50 lb. per sq. in., after which hot creosote from the working tank is pumped into the cylinder from which (the original pressure still being maintained) the compressed air is allowed to escape. When the cylinder is filled with creosote the pressure is raised to 125 to 200 lb. per sq. in. During this oil-pressure period the temperature of the oil is maintained at about 190 deg. F. When the predetermined absorption of oil, known as the gross absorption, has been secured, or when the wood will absorb no more oil, the pressure on the cylinder is released and the oil is pumped back to the working-tank. With the release of the pressure there occurs a "kick-back" of oil from the wood, caused by expansion of the air compressed in the wood cells during the "initial air pressure" period. This kick-back may expel from the timber as much as 50 per cent of the gross absorption of oil, which the oil pump returns to the working tank. A final vacuum of at least 20 in. is then drawn on the cylinder. This increases the expansive force of any compressed air remaining in the wood, and thus withdraws still more of the oil that was forced into the wood during the pressure period. The vacuum is continued until the drip of oil from the wood ceases and the surface of the timbers is fairly dry. The vacuum is then broken, the cylinder door is opened, and the charge of wood withdrawn. The amount of oil now actually remaining in the treated timbers is known as the net absorption.

From the foregoing description of the Rueping process, it is evident that penetration of the wood is accomplished with a minimum consumption of creosote oil. With round timbers of non-refractory species a recovery, from kick-back and vacuum drip, of 70 per cent of the gross absorption may be secured by certain manipulations of the initial air and oil pressures. The process is quite extensively used, but whether it is equal to the full-cell process in the degree of protection afforded timber against decay is a debatable question that must be considered in conjunction with the cost of the oil, the proposed uses of the treated material, salvage value, and other points.

BOILING-UNDER-VACUUM

This is not exactly a treating process, but is a method of preparing green timber for treatment by artificially seasoning the timber in the treating cylinder. It is generally recognized that it is not possible to force a preservative into wood, the cells of which are already full of water. Green wood contains a considerable quantity of water, sometimes amounting to over 50 per cent of the weight of the green wood, or over 100 per cent of the weight of the oven-dry wood. Before a preservative oil can be injected into green timber a large portion of this contained water must first be removed; in other words, the moisture content of the wood must be reduced. Some species of timber suffer a considerable reduction in strength when processed at high temperatures, and, in order to vaporize and remove the moisture in the wood (that is, to give it an artificial seasoning) and to do this without having recourse to high temperatures, the wood is boiled in oil under a vacuum as follows:

The green wood is run into the cylinder, which is then closed and filled to about two-thirds of its height with oil heated to about 200 deg. F. in the working tank. This temperature will drop to about 180 deg. F., or lower, when the oil comes into contact with the wood in the cylinder. A vacuum is then drawn on the cylinder, and this vacuum is maintained throughout the seasoning period, during which time the temperature in the cylinder is held between 180 and 220 deg. F. As the timber becomes heated by the oil, the moisture in the wood vaporizes under the reduced pressure and is drawn off through a condenser by the vacuum pump. This vaporization of the water causes foaming within the cylinder, and to prevent this foam (a mixture of water vapour and liquid oil) from being carried into, and quickly filling the condenser, the vapours are led through a tall goose-neck piping mounted vertically on the cylinder and extending to a height of about 30 ft.*

The seasoning continues until the condensate removed from the timber is approximately 1/10 lb. per cu. ft. of

*An experimental device for breaking up the foam, developed at the Forest Products Laboratories, permits the cylinder to be filled to within a few inches of the top, the vapours only being allowed to pass into the condenser.

timber per hour. This point may not be reached until after a long period—often 20 hours—and it is determined by examination at intervals of the amount of condensate in the drip tank. The foaming in the cylinder, which is violent at the beginning of the operation subsides after a few hours and permits more oil to be drawn into the cylinder to cover the wood completely. After the timber has been seasoned, the cylinder is completely filled with oil without breaking the vacuum. Pressure is then applied and the treatment is carried out at an average pressure of 175 lb., and an average temperature of 180 deg. F., as already described in the description of the full-cell process. If the timbers are to be treated by the Rueping process the cylinder is emptied of preservative after the boiling-under-vacuum period. The timbers are then subjected to air pressure of sufficient intensity and duration, to provide, under a final vacuum, for the ejection of surplus preservative and to ensure the retention and proper distribution of the stipulated amount of preservative to be left in the timbers. The preservative is then introduced into the cylinder and the treatment carried out as in the Rueping process.

Seasoning by boiling-under-vacuum is practised extensively in plants on the Pacific Coast engaged in the treatment of green Douglas fir ties, timbers, and piling. It is not often resorted to in plant operations in Central or Eastern Canada, where all material is generally air-seasoned before treatment.

## TREATED CANADIAN TIMBER PRODUCTS

### Railway Ties

The following species are used for ties in Canada, both treated and untreated; jack pine, lodgepole pine, red pine, white pine, spruce, eastern and western hemlock, Douglas fir, and oak. Tamarack and cedar are used untreated. Yellow birch, hard maple and beech are used when treated.

With the exception of the treatment of a limited number of ties with zinc chloride, for use in Alberta and Saskatchewan, creosote has been the preservative in general use for the treatment of ties. In the east, 20 per cent of tar was mixed with creosote for several years, and this has been increased to 30 per cent in recent years. In the west, crude oil could be purchased more advantageously than tar, and from 30 to 50 per cent has been mixed with creosote to provide a cheaper treating mixture. In the period from 1913 to 1924, a net absorption of 8 to 10 lb. per cu. ft. was used. The rising price of creosote and the adoption of the incising process, caused and permitted respectively, a reduction of the net absorption to 6 lb. per cu. ft. It has recently been possible to increase the preservative to 8 lb. at some plants. When using a 50/50 creosote crude oil mixture instead of a 70/30 creosote coal-tar mixture, it has been customary to increase the net absorption by at least one pound.

It is difficult to obtain records of the service life of different species of ties in Canada, since renewals are made individually as the ties wear out in service, and a very intensive system of inspection is required, since a section of track may contain ties of different species, treated and untreated, and installed in different years. It is only since 1920 and 1921 that tie treatments have attained any volume in Canada. Consequently, the majority of the treated ties in use have not been in service long enough to obtain extensive data on the service life, but it is sometimes considered that the average life will be about 25 years, judging by the present condition of some of the older ties. This compares with an untreated life of 5 to 9 years for softwoods and 4 to 11 years for hardwoods.

The percentage of railway ties treated in Canada from 1922 to 1932 inclusive is as follows: 16.7, 24.4, 18.9, 16.5, 28.0, 33.1, 30.6, 30.1, 27.5, 38.7, 33.1. Average for 11 years—27.7.

### Telegraph and Telephone Poles

The chief advantage to be derived from the preservative treatment of telephone poles is that species with suitable taper, high strength value, but lacking in natural durability, can be utilized when treated. In Canada, untreated eastern and western cedar have been used extensively for poles, and of recent years a considerable number have been butt-treated with creosote. In Canada, for many years, untreated cedar poles proved quite satisfactory, and the average service life often exceeded the average plant life, that is the poles were changed by reason of increasing loads calling for larger poles, or moved on account of street or highway widening, or for similar reasons, before they failed from decay. In future, a larger percentage of poles will be placed under more stabilized conditions and the 35-year life of creosoted poles used to advantage. The question of continuity of service is now of great importance, and the freedom from failure during sleet storms shown by the stronger treated pine poles is very advantageous.

### Marine Piling

Timber construction is very suitable for port and harbour structures, the chief advantage being that as conditions change and larger wharves are required, wooden wharves can be altered and enlarged. The greater resiliency of wood as compared with stone or concrete is also of definite value in connection with the berthing of ships. With regard to permanency, most structures are out of date before treated timber has reached the end of its useful service life of about 35 years. In sea-water timber must be protected from marine borers, and since water-soluble preservatives will, of course, be rapidly leached from the woods, the choice of preservatives is more limited than in the case of protecting wood from decay. Creosote, however, has been found to be quite satisfactory provided an adequate quantity is used. 14 to 18 lb. per cu. ft. is required for round piling.

### Foundation Piling

Formerly the use of untreated wooden foundation piles necessitated cutting the piles off below low water mark in order that they would always be saturated with water, and thus be immune to decay. Trouble sometimes occurs due to a lowering of the water table, and the consequent failure of untreated piling. Creosoted piles buried in the earth and capped with concrete footing are protected from decay, and are being used increasingly for permanent construction irrespective of the water level.

### Mine Timbers

The rapid development of the mining industry in Canada, in particular the metal mines, has been accompanied by increasing consumption of timber products, and in 1935 about $5,000,000 worth of lumber was utilized by the mining industry. The tendency in mining operations is to utilize the cheapest and most available timber situated near to the mine, and probably the greatest advantage to be derived from the preservative treatment of mine timbers, is the resulting conservation of timber supplies, which are situated close to the mines, and, of equal importance, is the fact that species of low natural durability can be utilized when treated. In nearly every mine there are certain permanent or semi-permanent timbers that can be treated to advantage such as shaft and slope timbers, entry timbers, drift timbers and ties.

The preservatives most commonly used for the treatment of mine timbers are zinc chloride and creosote. Others that have been used are sodium chromate, arsenic, mercuric chloride and zinc sulphate.

Table I. Average Treating Schedules

| Species | Treating mixture | Boiling under vacuum | | | Oil bath | | Initial air | | Oil pressure | | | Gross absorption | Final vacuum | | Net absorption | Total time treatment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hours | Temp. deg. F. | Inches | Hours | Temp. deg. F. | Lb./sq. in. | Hours | Lb./sq. in. | Hours | Temp. deg. F. | Lb./cu. ft. | Inches | Hours | Lb./cu. ft. | Hours |
| Douglas Fir No. 1 Green | 50/50 creosote crude oil | 12½ | 200 | 17-21 | | | 70 | ½ | 150 | 1 | 155 | | 24 | 1½ | 8 | 15½ |
| Douglas Fir No. 1 Seasoned | 70/30 creosote crude oil | | | | 3-6 | 190 | 75 | ½ | 150 | 4-7 | 180 | 10.9 | 24 | 1½ | 8 | 11 aver. |
| Jack Pine No. 1 Seasoned | 70/30 creosote coal tar | | | | | | 65 | ½ | 190 | 3 | 195 | 14.6 | 24 | 1 | 7 | 4½ |
| Birch, Beech, Maple No. 2 Seasoned | 70/30 creosote coal tar | | | | | | 50 | ½ | 175 | 2½ | 195 | 13.4 | 24 | 1 | 7 | 4 |

LUMBER AND STRUCTURAL TIMBERS

The preservative treatment of structural timbers has been increasing each year, the most important item probably being the treatment of bridge timbers. The railway companies have made extensive use of treated timber for bridges and trestles, and the highway departments are following their example. In the construction of highways a great advantage of treated timber is that, when a bridge requires widening or strengthening, it can readily be carried out, when constructed of treated timber, or, if the site is abandoned, the treated timber has a higher salvage value than any other material.

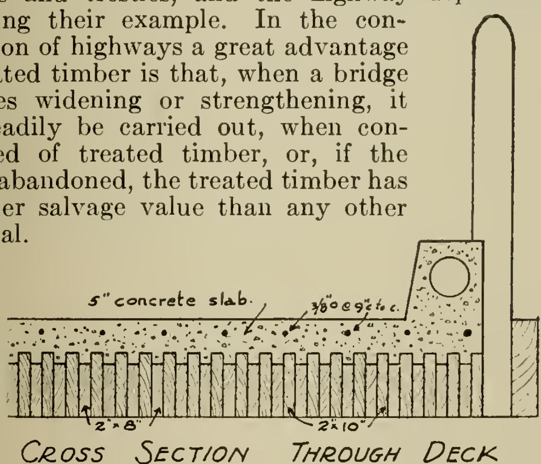


**Fig. 7—Construction of roadway for composite bridge illustrated in Fig. 3.**

The treatment of component parts of buildings such as sills, joists, sub-flooring, nailing strips, rafters and roofing planks has increased steadily. In amusement parks many structures can be constructed of treated wood such as stadium seats and bleachers. On farms, small outbuildings, chicken houses, fences and gates will present a neat and tidy appearance during long years of service, if constructed of treated wood. For irrigation projects, creosoted flumes, wood stave pipe, gates and diversion boxes are serviceable and economical. There are also numerous miscellaneous uses for treated wood such as retaining walls and cribbing, septic tanks, ice-houses, loading platforms, water tanks, scows, etc.

TREATING SPECIFICATIONS

The pressure treatment of timber is quite simple, and the only problem is to leave exactly the specified quantity of preservative in the timber, and to distribute the preservative so that a deep and uniform penetration is obtained.

Specifications for the purchase of pressure-treated timber should stipulate the process, the net retention of preservative, the maximum and minimum temperatures, and the maximum and minimum pressures to which the particular species of timber should be subjected in the treating cylinder.

Table I gives some representative treating schedules used in Canada.

The penetration requirements should call for the treatment of all of the sapwood and as much of the heartwood as practicable. Owing to the erratic nature of the penetration of preservatives in heartwood, it is very difficult to state what the average penetration should be for a particular size and species of timber treated with a given quantity of preservative. A very great deal of work would be required to determine the number of borings for penetration and the number of pieces to be bored per charge in each size of timber product, so that the average penetration required could be safely specified without leading to the unwarranted rejection of treated timber. The incising process helps to secure a more uniform penetration of preservative, and should be specified for square timber whenever possible.

To date treating specifications for Canadian timbers have not been issued by any association, but the Canadian Engineering Standards Association will shortly publish a specification for wood piling, which will include a treating specification, and it is hoped that this will be followed by other specifications dealing with treated Canadian timber products.

Until such time as Canadian specifications are available, the "Manual of Recommended Practice," issued by the American Wood Preservers Association, will be found very useful.

# Synthetic Plastics in Aircraft Construction

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**Paper presented to the Aeronautical Section of the Ottawa Branch of The Engineering Institute of Canada, on March 4th, 1937.**

The synthetic plastics have a unique combination of properties which makes them exceedingly interesting as materials for aircraft construction. In comparison with wood, they are almost fireproof, much less susceptible to deterioration by water and weather, and are prepared in the desired shape by moulding.

In comparison with metal, they are lighter and non-corroding. They damp vibration and they are electrical insulators. Their surface is naturally smooth and requires no protective coating.

### Types of Resins Available

The synthetic resins are simply materials which have the appearance and characteristics of natural resins but are produced synthetically.

While the natural resins are usually marketed in the form of lumps or flakes, the synthetic materials are more often ground and mixed with filler and sold as moulding powder.

Nearly all of the synthetic resins have the property of becoming plastic at elevated temperatures. Those which have this characteristic are properly known as plastics. In the process of moulding, a mass of plastic material is subjected to simultaneous heat and pressure whereby it takes the desired shape and is then termed a moulded product.

There is an unfortunate tendency to apply the term "plastic" to both the moulding powder and the finished product. In most cases the moulded article is permanently hard and it is misleading to refer to it as a plastic.

The world production of synthetic resins is said to be about 70,000 tons each year. Of this amount 30,000 tons or nearly half is used in varnishes. The remaining 40,000 tons is used for the manufacture of moulded products.[1]

Synthetic resin varnishes are used extensively on airplanes and might well be included under this title. The average airplane today probably carries more synthetic resin in the form of varnish than in the form of moulded products. The introduction of this material into varnish constitutes the greatest advance in the paint and varnish industry in the last decade. The hardness, flexibility and durability of these varnishes places them far above the old type in quality.

Mention should be made of the cellulose derivatives although these cannot be called strictly synthetic. The cellulose part of the molecule comes from wood or cotton and is the essential part of the material. The chemical modification of it is a secondary feature.

The available types may be classed as follows:

*Class I, Natural Polymers*

(*a*) Cellulose derivatives (acetate, nitrate, ethyl, benzyl);
(*b*) Casein;
(*c*) Shellac.

As far as moulded products are concerned, cellulose nitrate is too inflammable for airplane use. It also deteriorates under the action of light.

Ethyl and benzyl cellulose are relatively new and show promise. Cellulose acetate is the important material in Class I.

Both casein and shellac are affected by moisture and are inferior to the true synthetic resins in other respects.

[1] Fonrobert, British Plastics, Jan. 1937, p. 375.

*Class II, True Synthetic Resins*

(*a*) Phenolic type, e.g. phenol-formaldehyde;
(*b*) Urea type, e.g. urea-formaldehyde;
(*c*) Alkyd type, e.g. glycerine-phthalic anhydride.

The phenolic type has probably the widest use and is regarded as the most promising in this class for aircraft use. The urea resins have poorer moisture resistance and display no advantage in strength. The alkyds are not primarily moulding resins. They may be cast, sheeted or extruded. Their greatest use is probably in varnishes and enamels.

*Class III, Synthetic Polymers*

(*a*) Acrylic type, e.g. polymethyl methacrylate;
(*b*) Vinyl type, e.g. polyvinyl acetate;
(*c*) Styrene type, e.g. polystyrene;
(*d*) Synthetic rubbers.

The distinction between resins and polymers is chemical and refers to the mechanism of their formation. The resinous materials are generally coloured and are thermosetting while the polymeric materials are more often obtained colourless and transparent; most of them are permanently thermoplastic.

In practice both classes are usually referred to as resins.

The acrylic type is not only the newest but probably the most important of this group. It appeared on the market in England and the United States only within the last year or two and is sold under such names as Perspex, Luglas, Plexiglas, Acryloid and Lucite.

The vinyl type has good properties in general but has a tendency to cold flow and is not entirely unaffected by light.

Polystyrenes have exceptionally good electrical properties and are useful wherever such characteristics are especially important. They are probably too expensive for ordinary moulding. Their water absorption is zero.

The synthetic rubbers do not come within the scope of this survey. They may become important in aircraft on account of their resistance to sunlight and to oil.

### Propellers

During the war propellers were used in the United States which were made of a phenolic resin product called Micarta. This is a laminated phenolic material and is still on the market in the form of sheets for wall coverings and counter tops. It is made up by saturating sheets of cloth or paper in the soft resin and bonding a number of layers together in a heated hydraulic press. These propellers were apparently satisfactory but have not come into general use.

A more recent development is the coating of a wood propeller with a thick layer of resin. This is the Schwarz process, which is used in Europe. After a preliminary treatment of the wood, a sheath of cellulose acetate is placed over it and is then bonded securely to the wood by heat and pressure. The result is a smooth, moisture resistant and abrasion resistant surface. The member has the tensile strength of wood and the durability of a synthetic resin.

It has been proposed to manufacture a controllable pitch propeller having moulded blades attached to a metal hub.

A possible development is the impregnation of wood propellers with a resin by a recently developed process.

The result of impregnation is to increase the strength and weight in about the same ratio but water resistance and durability are greatly improved.

The production of a moulded propeller from pure resin is technically possible but is open to a number of objections. In the first place, it would be twice as heavy as wood with little or no advantage in strength. In comparison with duralumin the moulded propeller would have much poorer strength characteristics. On the other hand it would be lighter, less subject to fatigue and non-corroding.

### Engine Parts and Accessories

Moulded products may not be used where they are exposed to the full heat of the engine. Like all organic materials, they will burn at temperatures higher than about 200-300 deg. C. (400-500 deg. F.). The phenolic resins are the most resistant to heat. However, many of the accessory parts may be made of moulded products for lightness and cheapness. Distributor caps have long been moulded of phenolic resin, hard rubber having been abandoned during the war.

Other parts which can be made from plastics include water pump impellers, timing gears, insulators, washers, bushings and small housings.

The use of moulded instrument panels, instrument cases and of translucent dials is now quite common. Even if weight were not a factor, they have many advantages over wood, metal and glass. Control knobs, switches and radio parts made from plastics are also standard. Control levers can be made of plastics moulded on a metal core.

The most common materials for these purposes are cellulose acetate and phenolic resins. Cellulose acetate is somewhat more expensive but is tougher and more pleasing in appearance. The larger parts (instrument panels and cases) are more likely to be made of phenolic resins.

### Structural Parts

The tensile strength and transverse breaking strength of the moulded products is inadequate for parts such as spars, ribs and struts which are subject to severe stresses in use.

| Material | Specific[2] Gravity | Tensile[2] Strength lb. per sq. in. |
|---|---|---|
| Phenolic | 1.35 | 7,000 |
| Acrylic | 1.2 | 8,000 |
| Phenolic (laminated) | 1.37 | 10,000 |
| Duralumin | 2.85 | 50,000 |
| Steel | 7.8 | 100,000 |
| Spruce | 0.4 | 10,000 |
| Birch plywood | 0.8 | 15,000 |

The laminated phenolic products can compete with cast aluminum alloy for parts requiring relatively low tensile strength, i.e. up to 30,000 lb., when the saving in weight is taken into consideration. They are not suitable for places where the highest structural strength is needed.

Laminated phenolic products in sheet form have been suggested for cowling and covering of wings and fuselage. The acrylic ester resins have not yet been offered in laminated sheets and it is likely that they will be more serviceable than the phenolics, being lighter and tougher.

This form of covering has two advantages which may not be immediately apparent. One is the natural smooth surface which results in a minimum skin friction drag. The second is the property of absorbing or deadening vibration.

The laminated board would appear to be eminently suitable for wall covering in cabins and freight compartments.

A possibility which has not been explored is the manufacture of resins in a sponge structure for wings. It is quite simple to prepare a resinous mass with a great number of voids and having a specific gravity as low as 0.3 with reasonable strength. Even lighter grades can be made for sound or heat insulation.

[2] Average figures from various sources.

### Organic Glasses

One of the earliest uses of plastics on airplanes was in the preparation of safety glass. It is now generally used in laminated glass in cabin windows of transport planes. Originally cellulose nitrate, this material gave way almost entirely to cellulose acetate and the latter is yielding in turn to vinyl and acrylic products.

Sheet resins without glass are now used for windshields and cockpit enclosures. Cellulose acetate is preferable for this purpose, the nitrate being too inflammable. When plasticized with triphenyl phosphate, cellulose acetate is practically fireproof.

The vinyls and acrylic esters may replace cellulose acetate sheet for this purpose also.

These products are known as organic glasses and are likely to come into wide use not only in aircraft but for ordinary building purposes. The windows in the airship Hindenburg were of acrylic resin sheet.

The organic glasses are about one quarter the weight of glass, the visibility is as good and ultraviolet transmission is much higher. While they are subject to scratching and wear, replacement is simple. Their light transmission is over 85 per cent. The acrylic glasses are the most resistant to scratching while the polystyrenes have the greatest hardness.

Transparent Sheet[3]

| | Scratch resistance | Indentation hardness |
|---|---|---|
| Cellulose acetate | 9 | 7 |
| Cellulose nitrate | 10 | 11 |
| Ethyl cellulose | 6 | 6 |
| Acrylic resin | 15 | 14 |
| Vinyl resin | 10 | 15 |
| Styrene resin | 11 | 20 |

The recently formed Plastics Division of the Bureau of Standards at Washington has devoted considerable attention to the organic glasses.

### Conclusion

Miscellaneous uses for plastics include the manufacture of heavy duty bearings. These have been very successful in industrial use and might be used to a limited extent on aircraft, with a resultant saving in weight. A phenolic resin glue is now used for making waterproof plywood. The material has remarkably good water resistance.

General methods of testing moulded products have been well developed and are in everyday use. A specification for phenolic resins and moulded products is shortly to be issued by the British Standards Institution. It will contain complete details of the methods of test.

The trend is therefore toward the use of plastics for making small parts, for transparent sheets to replace glass, in laminated sheets for covering large areas, and for incidental use in various places.

The moulding of large shapes is difficult and their strength is not high enough to warrant their use in structural parts. The discovery of high strength plastics and of simplified moulding methods may occur in the future. If such a development does come, it will be a gradual process and one will probably find moulded products becoming larger and larger until the construction of a complete wing from moulded shapes may conceivably be accomplished. As a commercial possibility this is some distance away.

The use of plastics for the purposes mentioned is, however, a large and increasing one and represents a considerable advance in the technology of aircraft.

[3] Kline and Axilrod, Modern Plastics, Jan. 1937, p. 35.

DISCUSSION ON

# The Characteristics and Application of Modern Electric Relaying

*Paper by E. M. Wood[1] published in The Engineering Journal, May 1937*

P. ACKERMAN, A.M.E.I.C.[2]

In the opinion of the writer, stepped distance protection represents for our conditions the most universal principle for line protection, satisfying, for most power systems, practically all requirements for selectivity and speed of clearance.

The pilot principle, as far as its application to overhead systems, covering wide areas, is concerned, will remain a refinement, applied only in case of short tie lines which may be beyond the stepped distance principle; or in special cases, where extra clearing speed may prove particularly desirable. The ultimate form of high speed pilot protection will not necessarily be the one described by the author. Such pilot protection will probably be rather superimposed on an ordinary distance protective system, using for this purpose the standard distance relay equipment for the a.c. function, and for the pilot circuit whatever communication circuit will best fit into the specific case. Where speed of clearing is the main motive of the pilot protection, schemes which will transfer a trip impulse, rather than a blocking impulse, should prove advantageous.

The writer fully concurs with the author that high speed protection, coupled with re-closing feature, has many open fields for development.

A warning should be sounded regarding the use of special pilot protection to prevent trip-out on wide swings, or out-of-phase conditions between power sources. This is a risky way of tackling this problem. The only basic solution is to speed up the fault clearance, or to arrange the system layout so as to avoid serious voltage dips between synchronous systems parts, so that no instability or wide swings will occur at all.

As has been pointed out, most of the characteristic methods of high speed relaying, as described in this paper, have been applied extensively on the system of the Shawinigan Water and Power Company since 1920. By 1930 the main system of this company was almost entirely equipped with instantaneous system protection, at a time when other systems only started to make some timid attempts in this direction. True, what was called in those days "instantaneous," represented a total clearing time of approximately 5/10 of a second, whereas today total clearing times of 5/100 of a second can be obtained. This is 1/10 of what was considered quick clearance in 1930.

Except for stability reasons, no such extreme high speeds, however, are actually required to assure the full benefit of avoiding power arc damage and station oil fires. This is best proved by the records of the Shawinigan system, where instantaneous clearing times still range approximately between 0.2 to 0.5 seconds. The following extracts from records for the five-year period 1931-35, as published in a Bulletin on Shawinigan Engineering Features (September 1936), show the beneficial effect obtainable from such instantaneous protection, even at these slower instantaneous clearing speeds:

1. Of 1,400 circuits, cleared by relay protection during the five-year period from lightning flashovers, only 32 circuits were permanently damaged, that is, slightly over 2 per cent, whereas in the other 98 per cent of outages, the circuits went back immediately into service.

2. Of 145 station troubles, cleared by instantaneous zone protection during the five-year period, one-half of these troubles were momentary flashovers, where the instantaneous protection prevented power arc damage, permitting immediate resumption of service on the respective apparatus. During that period there were no cases of a serious oil fire.

Such records as mentioned indicate how, by persistent efforts, full control over a hazardous situation can be attained. The significance of such progress can best be appreciated by power house operators and line maintenance gangs of former days who used to be called out at any time of the night into severe storms to try to locate a damaged transmission line in utter darkness, or to fight a pernicious station oil fire.

This progress in speeding up the power system protection is particularly gratifying as it represents the final goal, for the attainment of which the writer has been fighting for the past twenty-five years.

F. F. AMBUHL[3]

The author has covered the subject in a very able and interesting manner. The extensive development during the past eight years in producing suitable relays to meet the many requirements imposed by the varied applications and operating conditions is something for which the operating engineer is truly grateful. This development is due in a large measure to the close co-operation of the engineers of both the operating and manufacturing companies. The improvement seems to have been fairly general in all types of equipment where relays are employed. Of the many supervisory and control systems which were placed in service eight or ten years ago only a few of these are now supplied in their original form. Considerable trouble was experienced with most of the early supervisory equipment though very little difficulty is experienced at present in obtaining equipment which may be considered quite satisfactory.

In the field of electric power generation and distribution, the benefits derived from the high speed clearance of a faulty section or element through the employment of high speed relays in conjunction with high speed cirucit breakers, cannot be easily over-estimated. Studies of system stability have shown that in general, the most effective method of accomplishing this result is the high speed clearance of the faulty section or element. Other methods may be and have been employed to increase the limit of stability though in any case the maximum results cannot be obtained unless high speed clearance is employed. While the clearing time depends on the type or nature of the fault, the allowable variation in clearing time is very small. Taking the worst condition, that of a three phase short circuit, the clearing time should be from 0.1 to 0.2 seconds, whereas with a single-phase-to-ground fault a clearing time of from 0.2 to 0.4 seconds would probably be found satisfactory.

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[2] Consulting Electrical Engineer, Montreal.

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Selective high speed clearance of faulty lines and equipment on large low voltage systems (12,000 volts and under) is also of the utmost importance as the failure to isolate a faulty section or element before it involves other equipment has in many cases resulted in the destruction of a large amount of equipment. Even on the low voltage networks where the entire secondary network is connected solidly together, continuity of service is dependent on high speed clearance of any faulty transformer or primary feeder supplying the network.

F. C. Barnes[4]

The field of protective relaying has become so extensive in the last few years that it is practically impossible to cover in one paper even a résumé of the certain problems which are common to most relay applications and until recently the difficulties involved in relaying under certain conditions have not been very thoroughly analyzed. The author indicates in his paper some of these difficulties and suggests various methods which have been used to overcome these troubles successfully.

In connection with very high speed differential protection for transformer banks, there are available on the market, relays capable of operating in one cycle or less, but experience in recent years with high speed transformer protection does not substantiate the increased benefits to be derived in the light of other factors. It has been proved in the field, that with relays operating at such high speeds, extreme care must be taken in choosing current transformers with suitable characteristics, so as not to cause false operation during heavy through short circuits, in which offset current waves are involved. Unless both the high tension and the low tension current transformers transform the offset waves nearly identically, false relay operation may result when using relays which operate in less than six to eight cycles. In the case of power transformers, where the current transformers on either side are of different types, such matching of characteristics is an expensive if not an almost impossible job.

In most cases, the difference in cost of repairing a transformer in which a fault persists for nine or ten cycles (assuming a breaker time of eight cycles and one or two cycles of relay time) is not materially different from that required where the fault lasts for fifteen cycles. With a synchronous machine it is different for here the repair may involve replacing iron which is generally not necessary in transformer repairs.

On some recent installations, high speed relays have been used on the generator circuit, where current transformers could be very carefully matched on both sides of the winding, due to the fact that they are of the same type, rating and design. Very high speed relays have been used on the transmission line but, on the transformer bank, relays operating in six to eight cycles have been used without any detrimental effect due to increased damage in the transformer because of the longer clearing time for a fault and without any danger of instability due to the slower tripping.

In some cases where high speed transformer differential relay applications have been made and where the bank is to be energized from the high tension side, the use of a potential transformer and undervoltage relay has been recommended. The contacts of the undervoltage relay are used to apply voltage restraint to the high speed relay raising its operating point from, say two to to eight amperes only for a second or two during the period of energizing the transformer. As soon as voltage appears on the secondary side the voltage relay picks up and removes the restraint from the relay. The only disadvantage of this scheme appears to lie in the fact that the sensitivity of the relay is decreased at a time when a fault is most likely to become apparent, although other engineers have indicated that if the transformer is sound when taken out of service it is unlikely to be faulty when put back into service.

G. R. Davis, A.M.E.I.C.[5]

The author's remarks on the improvement of present relay schemes are particularly interesting and timely in that there are many systems where the relaying has become too slow for most efficient operation and it is imperative that either the present relaying be improved or that complete new relaying be installed. As the improvement is the less costly it is the method that will usually be tried before scrapping present relaying.

Ten or twelve years ago on the smaller systems protected with inverse definite time relays of the induction disc type it was common practice to have minimum definite time settings of several seconds. As generating station capacities increased and the systems became interconnected with other systems it became necessary to shorten these times to at least one second wherever possible.

The benefit of clearing faulty lines in a comparatively short time was seen immediately insofar as system stability was concerned and the only thing that prevented even shorter time settings being used with induction disc relays was the matter of selectivity of one line section with another.

On systems with many small generating stations comparatively far apart and connected by transmission lines, numerous loops were formed by these lines and by lines to load centres. It can readily be seen that on such a system it was impossible to make relays selective on a time basis only and as the current available to operate a line relay depended on the number of generators connected to the system at the time of the fault it was not always possible to depend on the relay reaching a minimum definite time value. The relay settings finally used were more a result of experience than of calculations because so many different system connections were possible and experience only could determine the settings that gave the least faulty operations and unnecessary interruptions.

In laying out new relay schemes for this style of system layout it would seem impracticable to determine all new current and time settings by calculations only and disregard the old settings that had been determined largely by years of experience. The better method would be to superimpose instantaneous overcurrent or impedance features on the present relaying and gradually adjust settings to give more efficient results. With system generating capacity other than normal the present relaying would not be affected in any way and with system capacity normal the added features would clear the faulted sections instantaneously and system stability would be decidedly improved.

From a stability viewpoint pilot wire relaying on short lines has proved most satisfactory but as mentioned by the author the cost is usually prohibitive.

E. W. Knapp, A.M.E.I.C.[6]

The author has managed with considerable success to cover his subject in a condensed but nevertheless thorough manner but the writer would like to review the protection problem from a somewhat different angle.

In the not-very-distant past, protection relays were accepted by the engineering staff as a necessary evil and welcomed as an operating convenience by the operating personnel. At that time all protective gear, including relaying and switch-gear, was slow in operation and not

[4] Canadian General Electric Company, Limited, Toronto, Ont.

[5] Hydro-Electric Power Commission of Ontario, Ottawa, Ont.

[6] Shawinigan Water and Power Company, Montreal.

always effective or selective in action. The obvious result was extensive power arc damage, costly repairs and extended service interruptions.

As the power systems grew, power equipment became larger and more costly, transmission systems developed into networks and system interconnections became quite common. It then became apparent that effective and selective relaying was no longer a necessary evil, but an urgent necessity. In order to cope with the growth of the power system, the protection engineer was obliged to develop adequate protection schemes for each element of the power system, so designed that a faulted element could be isolated with a minimum of damage to itself as well as a minimum of disturbance to the interconnected system. Needless to say, this was a situation requiring a thorough understanding of the various elements of the problem and considerable initiative on the part of those responsible for relaying. This was particularly true in view of the limited amount of information readily available on the subject at that time, and the inadequacy of relays then available.

During this development period many experiments were tried with varied success. Some of these were successful and are still in use; others required considerable modification and still others proved unsatisfactory in practice and had to be abandoned. Considerable progress has been made during the past few years, not only in the development of new schemes of protection, but also in improved instruments to use in these schemes.

Relay protection is today an integral part of the power system. No system planning organization is complete without a representative of the Protection Department. Each element of the power system must be studied carefully in its relation to every other section, including the necessity or ability of providing an adequate relay protection. The design of the relay protection must be carefully correlated with the power system plan and available protective gear, including relays and switch-gear. If fast isolation of faults is required, then it is important that both switch-gear and relays have fast operating characteristics. The choice of relays is of paramount importance in any relay scheme, particularly on the network systems where system stability, selectivity and service continuity are important factors.

After the protection has been installed, it is necessary to have a maintenance organization to insure that all protective gear is kept in good condition. It must not be overlooked that this equipment is normally inactive, but when called upon, it must be ready to complete its job within a small fraction of a second.

Training of the operating and maintenance personnel is also an important section of the relaying organization. This is particularly true on those extended systems where outlying stations may be several hundred miles from the relaying organization. In this case preference is often given to simple and rugged schemes and instruments, requiring the minimum of attention. It has been found that supervisory and indicating lights, control switches and other conveniently arranged devices are of considerable assistance to the local station or district personnel, and these features very often form an important part of the protection design.

The author has mentioned such features as primary tests, automatic recording instruments, relay indicators, symmetrical components and instantaneous automatic reclosing and the writer is in agreement with the expressed opinions on these features. The Shawinigan Water and Power Company have adapted these features to their system and have found them helpful. They also correlate and analyze all data pertaining to each automatic operation on the power system. This procedure has proved of considerable value in locating and permitting the removal of defects on the power system, including protective gear.

In conclusion, the importance of the protective gear from a service viewpoint should be stressed and to emphasize the serious consequences from a damage and service viewpoint if this feature of the power system is not effective in every important function.

F. L. Lawton, m.e.i.c.[7]

This excellent paper has been read with considerable interest, as it presents a comprehensive survey of relay practice. However it would be appreciated if the author would discuss the following questions;

(*a*) What is the relative reliability of high-speed carrier pilot relay schemes, particularly of the component equipment?

(*b*) How does the cost of such relaying on, say, a 100-mile transmission line compare with conventional high-speed impedance relaying?

(*c*) Has it been possible to eliminate all faulty operations of current-differential protection schemes on low-voltage, 15 kv. and under, zones where through fault, currents of high value occur?

D. J. McDonald, Jr.e.i.c.[8]

The author has discussed the advantages which accrue to the power company which uses modern relaying systems.

When trouble occurs on a power system induced voltages appear on communication circuits which are in the vicinity of the power circuits affected. The magnitude of the induced voltage and its effects depend on the amount and duration of the residual current flowing in the power circuit. Anything which is done to reduce the duration and extent of the power system disturbance is therefore a direct benefit to communication systems, which operate circuits adjacent to the power circuits, as well as to the power company.

E. G. Ratz[9]

The author has pointed out the characteristics and advantageous features of induction types of relays. In discussing the protection for important transmission circuits there has been some tendency to criticize the induction type of relay unjustifiably when, as a matter of fact, it is the application of the relay which is in error rather than the relay itself.

It is true that the characteristics of the induction type relay can no longer be considered adequate for important main transmission circuits. Nevertheless the rugged, accurate and reliable characteristics of this form of relay make it ideal for the tremendous number of applications on branch feeder circuits, apparatus protection, etc., on which it is still used, without any real equal in regard to ease of setting for both current and time, these features all being combined in the one piece of equipment.

The induction type relay was first made in 1902 and has been used in continually increasing quantities ever since that time.

Induction type overcurrent relays can now be made with burdens of less than 1 VA at the tripping current and to operate in less than 2 cycles (60 cycle basis). When used as differential relays these induction relays have the great advantage that they largely ignore the troublesome transient currents which are the result of current transformer characteristics and are described fully on page 246 of the author's paper. Other types of relays which take cognizance of these current transformer secondary currents must be

[7] Electrical Engineer, Saguenay Power Company, Arvida, P.Q.

[8] Bell Telephone Company of Canada, Montreal.

[9] Canadian Westinghouse Company Limited, Hamilton, Ont.

set with higher currents to avoid them—and therefore with less sensitivity.

The fast induction type overcurrent relay just mentioned can also be made practically free from chattering and rebounding at the contacts—a feature of importance in high speed relay design brought out by the author.

In the case of high speed distance relays a fault within the range of the instantaneous zone should cause the corresponding relay element to operate in a cycle or two, and the arc resistance for the instantaneous range is therefore hardly of any consequence—because it has not had the opportunity to rise and lengthen. For the instantaneous zone the impedance relay therefore is the equal of the reactance relay in accuracy and has the great additional advantages of simplicity, ease of setting, and low cost. Further, where the lines are long the arc resistance, if any, adds at right angles to the reactance of the line and has therefore comparatively little effect on the "impedance" measured. In the case of the second or time zones a high degree of accuracy in the measurement of the distance to the fault is usually not necessary.

The form of carrier protection described by the author, when controlled by distance relays at each terminal, greatly facilitates the adequate protection of lines with branch circuits, or main line networks of the Y type when three or more main terminals are used. These are types of lines that have been very difficult to adequately protect heretofore, particularly when the branches of the lines have widely different lengths.

Ralph C. Silver, s.e.i.c.[10]

The author has covered his subject so well that it is difficult to offer much discussion. The following may, however, be of some interest.

In certain cases instantaneous overcurrent relays may be applied as a supplement to directional impedance relays or other protection employing directional relays. In case of a three-phase metallic short circuit just outside a line O.C.B. there will be no voltage on the directional relays and they cannot operate.

It is interesting to note that some of the restrictions which a few years ago were imposed on a system arrangement by the requirements of selective relaying and stability considerations are being removed by the development of high speed breakers, carrier current relaying and automatic reclosure. It should, however, be kept in mind that the system layout is still one of the most important factors in producing a stable system with simple and effective relaying.

The importance of various design details and accurate operating data has rightly been stressed. In dealing with high speed relaying even seemingly unimportant details may completely upset the correct working of a protection scheme.

The combination of high speed relaying and automatic reclosure will undoubtedly prove to be one of the major advances in modern relaying. There will also be a tendency to bring the advantages of high speed protection to the lower voltage and small capacity feeders through the use of instantaneous overcurrent relays. An induction type relay is now under development which will operate in $1\frac{1}{2}$ to 2 cycles at high currents, but which will have the normal inverse time characteristic at smaller currents. There should also be further simplifying of the relays themselves and of certain relay circuits. The use of electron tubes has rapidly increased during the last few years and although they have not been employed to any great extent in power system relaying, except for carrier current installations, they should be considered as a possible means of providing simplified and better relay systems.

Is it correct to assume that Curve $A$ in Fig. 5 is for slightly different circuit or load conditions than curves $B$, $C$ and $D$?

[10] Gatineau Power Company, Ottawa, Ont.

The Author[11]

In looking over the discussion one is impressed by the value of the information and opinions brought forward by the various contributors. Each has added something that was not treated at length in the paper but which was pertinent to the subject. The author concurs, without important reservations, in the opinions expressed and wishes to thank the contributors.

There remains only to reply to the questions asked.

Replying to Mr. Ralph Silver, curve $A$ of Fig. 5 on page 247 differs from curves $B$, $C$, and $D$ in that the fault location is 15 per cent of the line length away from the point shown, which accounts for the different shape of the initial part of the curve.

Replying to questions raised by Mr. F. L. Lawton.

(*a*) Regarding the reliability of the component equipment of high-speed carrier relaying, up to very recently there have been no installations in service in Canada. There are, however, a very considerable number in service in the United States and the author has reason to believe that they are operating successfully. Some early trouble with loss of adjustment of timing of the carrier sets has, we are advised, been overcome.

(*b*) The cost of relaying on a 100 mile line by carrier-pilot would be of the order of two to three times that of conventional high speed impedance relaying, not taking into account potential or current sources for the relays.

(*c*) In current differential protective schemes such as bus zones at 15 kv. or less, where there is very heavy through fault current, but where sensitive settings are necessary, the author has used a two-stage scheme consisting of one set of differential current relays of the maximum required sensitivity, timed at one-half second and supplemented by a set of high speed relays which are set above the transient unbalance but which are effective for all heavy faults. This combination has proved effective in stopping improper operations wherever used on zone protections which had given trouble. Mr. Ratz in discussing the paper mentions a high speed low-energy induction relay which might be useful in such cases.

[11] Electrical Engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ont.

# THE ENGINEERING JOURNAL

## THE JOURNAL OF THE ENGINEERING INSTITUTE OF CANADA

"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."




VOLUME XX DECEMBER, 1937 No. 12

## The Council and the By-Laws

The ever present question of amendments to The Institute by-laws is one to which Council has devoted a great deal of attention both at its regular meetings during the past year, and at the Special Plenary Meeting of the 14th June last. In this connection the principal points involved have been the character of our future relations with the various Professional Associations, the extent and manner of co-operation with them and the nature and breadth of the necessary by-laws providing for such co-operation.

The events which have led up to the present situation regarding by-law revision are thus of great interest to the membership. Their importance in relation to the future of The Institute is such that Council has directed the publication in The Journal of a statement informing members as to the action taken by Council in respect to them on various occasions during the past twelve months.

Such a resumé will be found in another column. It will be remembered that the results of the ballot on the proposals of the Committee on Consolidation were published in May 1937. Following this, at its meeting on May 28th, Council appointed representatives to confer with a local committee in Nova Scotia which was already studying the possibilities of co-operation between The Institute and the Provincial Professional Association there. Since that time the subject of our relations with the Associations has come up at practically every Council meeting, and it has developed that in certain provinces such as Nova Scotia, New Brunswick, Manitoba, Saskatchewan and Alberta, the problem might be regarded as comparatively simple. The number of members involved is not large, and it may well be that working arrangements for co-operation can be established with some of these bodies as soon as the Council is authorized to enter into agreements with the Associations concerned. But as regards the three larger Associations, the situation is essentially different. Their membership is larger and contains a greater proportion of Association members who are not in The Institute. There are also a considerable number of members of The Institute who do not belong to those Associations. For these and other reasons, the desirable objects, such as common membership, or uniform standards of admission as between the Associations themselves and with The Institute, seem more difficult of attainment in these cases.

At the present moment a point has been reached where the Council finds itself unable to support a series of proposed amendments which were put forward on October 1st by thirty-one corporate members. It is felt that under present conditions the interests of The Institute would be better served by a simple amendment giving Council the legal power to enter into an agreement with any of the Professional Associations. This decision was taken at the Council meeting which has just been held in Toronto, at which, after noting the marked diversity of interests, membership, and working conditions that characterizes the various Professional Associations, Council did not think it advisable to approve a series of by-laws which prescribe in detail a single scheme intended to be applicable in all cases.

The steps which Council has now taken as to agreements in Nova Scotia and New Brunswick, and which it is desired to legalize by the membership's approval of Council's proposal for a new by-law providing for the conclusion of agreements with the Associations, are however, in Council's opinion, an indispensable preliminary to further progress. On this account it is urged that Council's proposal, which will shortly be mailed to members and will be submitted for discussion at the Annual General Meeting, should receive the support of every member of The Institute.

## Committee on the Publications of The Institute

One of the recommendations of the Round Table Conference of Branch Delegates held at the time of the Semicentennial was that Council should give its early consideration to the publications of The Institute, and the Conference also submitted some definite suggestions with regard to The Engineering Journal. Council was of the opinion that the subject was too important to be dealt with without the fullest consideration, and therefore appointed a Committee to make a comprehensive study of the Publications of The Institute, and to report on any improvements or changes which may be found possible.

The personnel of the Committee is as follows:—

| | |
|---|---|
| R. W. Boyle, M.E.I.C., | National Research Council, Ottawa, |
| A. Duperron, M.E.I.C., | Chief Engineer, Montreal Tramways Co., |
| R. H. Findlay, M.E.I.C., | Mechanical Engineer, Dominion Bridge Co., Montreal, |
| F. S. B. Heward, A.M.E.I.C., | F. S. B. Heward and Company, Montreal, |
| J. L. Busfield, M.E.I.C. | (Treasurer of The Institute), Chairman. |

The Committee has held an organization meeting, and appreciating that the opinions of the membership are of fundamental importance in the development of The Institute's Publications, it has been decided to issue a questionnaire to the membership at large asking for specific information with regard to each member's preferences. After the replies have been received and studied, and the whole subject thereby brought to a focus, it is expected that a second questionnaire will be submitted dealing with proposals for the future.

Members will appreciate that the Committee's work will be facilitated by a prompt and universal reply to the questionnaire, so they are earnestly requested to take the few minutes necessary just as soon as the questionnaire is received.

## The Fifty-Second Annual General Meeting

Notice is hereby given in accordance with the By-Laws, that the Annual General Meeting of The Engineering Institute of Canada for 1938 will begin at Headquarters at eight o'clock p.m. on Thursday, January 20th, 1938, for the transaction of the necessary formal business including the appointment of scrutineers for the Officers' Ballot, and will then be adjourned to reconvene at the London Hotel, London, Ontario, at twelve o'clock noon on Monday, January 31st, 1938.

R. J. Durley,
*Secretary*

## The Late Lord Rutherford of Nelson

The news of the death of Lord Rutherford on October 19th, at the age of sixty-six, will greatly affect the many Canadians who knew him as Macdonald Professor of Physics at McGill University during the years 1898 to 1907. It was at this time that he made the first of the discoveries which were later to serve as the foundation of much of our present knowledge of radioactivity and the structure of the atom.

Born in Nelson, New Zealand, and a graduate of the University of New Zealand, Ernest Rutherford came to England and entered Trinity College, Cambridge, in 1894. There he worked in the Cavendish Laboratory, under Sir J. J. Thomson, investigating the newly discovered properties of ionized gases. He became interested in the problems of radioactivity which arose from the investigations of Becquerel and Curie, and soon after his appointment at McGill, and in conjunction with Frederick Soddy, obtained experimental results which provided an explanation of the disruption of the atoms of the radioactive elements. It was found that these unstable elements are being continually transmuted into other elements, as, for example, the change of the unstable uranium into the more stable element lead. This work led to his election as a Fellow of the Royal Society in 1903.

Leaving Montreal in 1907, he was appointed Langworthy Professor of Physics at Manchester University, and was awarded the Nobel Prize for Chemistry in 1908. Three years later, having established the existence of the atomic nucleus, he advanced a theory of atomic structure which aroused the interest of many other workers and has resulted in the development of the present ideas of atomic physics. He was knighted in 1914, and in 1919 returned to Cambridge, where he succeeded his old chief, J. J. Thomson, as Cavendish Professor and Director of the Cavendish Laboratories. From that date until his death he continued his work on radioactivity and the artificial disintegration of the elements, his services to science and the State having been recognized by the award of the Order of Merit in 1925 and by a peerage in 1931. He was the recipient of other degrees, prizes, medals and honours too numerous to mention here.

In addition to his engrossing occupation with radioactivity, Lord Rutherford found time for a considerable amount of public work, serving, for example, for seven years as chairman of the Advisory Council of the Department of Scientific and Industrial Research. He was an ardent advocate of research as an aid to the application of science in industry.

His leading personal characteristics were modesty, friendliness, remarkable skill as an experimental physicist, and striking ability to awaken in those who worked with him an enthusiasm comparable to his own.

The story of his life closes with his burial in Westminster Abbey, near the graves of Newton, Kelvin and Faraday.

## Fifty-Second Annual and General Professional Meeting London, Ontario

### January 31st to February 2nd, 1938

It was with pleasure that the Council accepted the suggestion from the London Branch that the Annual Meeting for 1938 should be held in that city. The event is a happy one, for while the large contingent of Institute members who live in South Western Ontario will no doubt furnish the main body of participants, London is such a pleasant rendezvous, and access by road and rail is so convenient, that a very substantial pilgrimage from more distant points may be confidently expected.

An active local committee, under the chairmanship of E. V. Buchanan, M.E.I.C., is working out the detail arrangements for a three-day meeting, of which the leading technical features will be the discussion of two questions of vital present day interest; namely, Safety on the Highways, and Flood Control and Water Conservation in South-Western Ontario.

The following is an outline of the programme as at present arranged. It is of course subject to minor changes.

**Monday, January 31st**

Registration, Luncheon, Annual General Meeting.

**Tuesday, February 1st**

Professional Session: Papers on "Engineering the Highways for Safety" and "Engineering Efficiency into the Highways."
Annual Dinner of The Institute.

**Wednesday, February 2nd**

Professional Session: A Symposium on Flood Control in South-Western Ontario with papers on: "Flood Control and Water Conservation in South-Western Ontario," "Agricultural Drainage in South-Western Ontario and its Effects on Stream Discharge," "Precipitation in South-Western Ontario" and "Stream Discharge and Run-off in the Thames and Grand Rivers."

Also, "Canadian Steam-Electric Power Plants" and "Large Pipe-Lines with Supporting Stiffeners."

Official Luncheon.

Special entertainment for ladies is being arranged by the Ladies Committee.

Visits to industrial establishments and public institutions in the vicinity of London are planned.

**New Dominion Public Building, London, Ont.**

Relief from the hard work of the professional sessions will be afforded by judiciously planned social functions, and by the hearty welcome which the London Branch will extend to all visiting members and ladies. The headquarters for the meeting will be at the **London Hotel.**

## The Institute's Relations with the Professional Associations

### Resumé of Recent Events

*January 29th, 1937.* The proposals of the Committee on Consolidation were discussed at the Annual General Meeting, and the proposed revisions to the by-laws were sent forward to ballot by the membership. A difference of opinion between Council and the Committee on Consolidation led to the submission of an alternative proposal by Council in respect to one section of the proposed amendments.

*April 30th, 1937.* The proposed amendments were rejected on ballot, with the exception of those not directly concerned with the consolidation scheme.

*May 28th, 1937.* Council was informed that a local committee in Nova Scotia was studying the possibilities of co-operation there between The Institute and the Professional Association. Discussions along similar lines were taking place in Saskatchewan and Manitoba. The President reported in regard to a visit to Winnipeg, made at the request of Council, to meet the members of the Winnipeg Branch and the members of the Manitoba Professional Association. He outlined the proposals for co-operation between The Institute and the Association in Winnipeg which had been under consideration there.

Mr. Busfield also reported as to his recent visit to the Maritime Provinces, made at Council's request, and stated that the Council of the Association of Professional Engineers of New Brunswick was also considering the matter. In compliance with a suggestion from Halifax, conveyed in Mr. Busfield's report, Professor H. W. McKiel and Mr. C. A. Fowler were appointed to represent the Council in the Nova Scotia discussions.

At the same meeting Professor R. A. Spencer and Messrs. J. L. Busfield and F. S. B. Heward were appointed a committee to make suggestions at the Plenary Meeting of Council as to the best method of dealing with problems relating to professional interests and the management of The Institute.

*June 14th, 1937.* The Plenary Meeting of Council and the Round Table Conference of Branch Representatives were held. At the Plenary Meeting, Council discussed the relations of The Institute with the Professional Associations in Nova Scotia, New Brunswick, Manitoba and Saskatchewan, and a resolution was unanimously passed expressing Council's desire to co-operate with all of the Associations. Professor Spencer presented the report of his committee, and, after discussion, it was decided to appoint a Committee on Professional Interests, and also a Committee on Membership and Management of The Institute. The former Committee, under the chairmanship of Past-President F. A. Gaby, with Past-President O. O. Lefebvre and Councillor F. Newell as members, is to deal *inter alia* with matters involving negotiations with the Professional Associations, without prejudice, however, to the negotiations in Nova Scotia, and is to work by the aid of provincial sub-committees. The latter Committee will investigate problems connected with the internal organization and functioning of The Institute, under the chairmanship of Professor R. A. Spencer, councillor from Saskatchewan.

*October 1st, 1937.* On this day proposals for the amendment of The Institute by-laws were received from thirty-one corporate members for submission to Council. These proposals comprise modifications of some of the important provisions submitted by the Committee on Consolidation in 1936, and propose the retention of the class of Associate Member; the automatic admission of corporate members of the Professional Associations, subject to classification by Council; the establishment of Component Associations, and of a Committee on Association Affairs; the payment by a Component Association annually to The Institute of a fee of 50 cents for each member of a Component Association licensed to practise; the payment by a Component Association whose corporate members are admitted as members of The Institute of a per capita annual fee to be determined by the Council, which shall include the per capita fee of 50 cents referred to, and an annual subscription to The Journal; the recognition of a new class of non-corporate membership to be called "Provincial Associates" and to comprise those members of an Association who do not become members of The Institute; the compulsory investigation by Council of the conduct of any member who may be expelled from a Component Association; the fixing of the entrance fee of The Institute for all corporate members at $15.00.

On a separate ballot two proposals are provided for—one to raise the quorum of Council from 5 to 11, and the other to limit the number of *ex-officio* members upon Branch Executive Committees to 4 (the latter provision affects the Montreal Branch only).

*October 8th, 1937.* The first draft of their report on the proposals for co-operation with the Professional Association in Nova Scotia was received from Messrs. McKiel and Fowler. This report had been prepared in conference with the representatives of the Association of Professional Engineers in Nova Scotia and of The Institute branches in Nova Scotia. A resumé of the report was sent out to members of Council.

*October 22nd, 1937.* Messrs. McKiel and Fowler attended the Council meeting and presented their report on the situation in Nova Scotia, outlining a scheme for co-operation between The Institute and the Professional Association which had been endorsed by the Council of that body and by The Institute branches in Nova Scotia. They recommended that Council express its willingness to enter into an agreement with the Association whereby The Institute would accept all members of the Association as corporate members of The Institute, while the Association would collect a single fee from all of its members, covering the annual fee to The Institute, a sum for the operation of The Institute Branches in Nova Scotia, and the annual fee to the Association. This arrangement would be conditional on all members of the Association joining The Institute.

After discussion, the meeting approved the scheme in principle, and it was directed that a letter ballot of Council should be taken as to Council's willingness to enter into such an agreement. It was noted that as the proposal would involve a change in the schedule of fees for Nova Scotia members, it would be necessary to obtain an amendment to the by-laws empowering Council to enter into an agreement of this kind.

At the same Council meeting, the proposals of thirty-one corporate members for the amendment of The Institute by-laws, which had been sent in on October 1st, were submitted for Council's consideration in accordance with Section 75 of the By-laws. It was noted that the proposers had authorized Messrs. Hector Cimon, Brian R. Perry and E. Viens to act for them in regard to any suggestions for the change or withdrawal of these proposals.

After discussion, it was the opinion of Council that in view of the report just received from Nova Scotia and the activities of the Committee on Professional Interests, it would be desirable to suggest to the representatives of the thirty-one proposers either the withdrawal of their proposals and the substitution of an amendment legalizing Council's action regarding the Nova Scotia agreement, or some modification of their proposals which would bring them more in line with Council's views as developed during the year. With this in mind a committee consisting of the President, Past-President Shearwood, and the Presidential Nominee, Mr. Challies, was appointed to confer with Messrs. Cimon, Perry and Viens.

In Council's view, the length and apparent complexity of the proposals of the thirty-one members, as well as the retention of many points of similarity with the consolidation proposals rejected on ballot, would make it very difficult to secure their acceptance by vote of the general membership, whereas a briefer and broader proposal would have a much better chance of obtaining the necessary majority. Further, Council felt that these proposals would be contentious and would tend to confuse the promising negotiations presently in hand with several of the Associations.

*October 29th, 1937.* The three representatives of Council conferred with Messrs. Cimon, Perry and Viens, and it was arranged that Messrs. Challies and Perry should endeavour to prepare briefer proposals (eliminating all unessential features), which would be acceptable to both parties, and could be submitted to Council at its next meeting on November 19th.

*November 16th, 1937.* At a second conference Messrs. Challies and Perry presented a compromise draft consisting of three sections additional to the existing by-laws, covering respectively the formation of Component Associations, with whom Council would be empowered to enter into agreements as to admission and members' fees; the representation of such Associations on Council; and the establishment of a special Standing Committee on Association Affairs.

After prolonged discussion, the representatives of the thirty-one proposers felt that, without consulting their principals, they could not express approval of the substitution of these three sections for the original proposals. Such consultation would take place as quickly as possible.

*November 19th, 1937.* At the Council meeting in Toronto held on this date, it was reported that on letter ballot a majority of councillors thought that Council should express willingness to enter into an agreement with the Nova Scotia Association. No negative votes were cast.

A similar request having been received from New Brunswick it was decided to take similar action in that case and to notify our representatives in both provinces of Council's favourable decision in both cases.

The President undertook to confer further with the parties concerned during his forthcoming visit to the Maritime Provinces.

In regard to by-law amendment, the President submitted the three sections drafted as a compromise and reported that they had not been acceptable to the representatives of the thirty-one proposers.

After full discussion, Council also felt unable to accept the suggested new sections and directed that the representatives of the proposers should be notified of this fact.

The members of Council present then agreed on the draft of a new section merely enabling Council to cooperate with any of the Professional Associations and enter into agreements with them in furtherance of the mutual interests of the members of The Institute and of the Associations, and in particular respecting the admission of their members to The Institute and the amount and method of collection of fees. It was directed that this draft should be submitted to all members of Council for approval by letter ballot before being put forward as a definite proposal of Council.

## OBITUARIES

### Harry William Dudley Armstrong, M.E.I.C.

Members of The Institute will learn with the deepest regret of the death of Harry William Dudley Armstrong, M.E.I.C., on August 2nd, at his residence in Toronto. He was 85 years of age and one of the first Members of the Canadian Society of Civil Engineers, having joined in January 1887.

Mr. Armstrong will be remembered for his regular attendance at annual meetings at The Institute and for having spoken during the business sessions of the last meetings in Hamilton and Toronto.

He attented private school in Ottawa and then became an articled pupil of Sir Sandford Fleming, then chief engineer of the Intercolonial Railway, in 1889. He was later with the Great Western Railway in the chief engineer's office on location and also on the surveys for the Detroit River bridge. In 1874 he was appointed assistant engineer with the Toronto Water Works, leaving in 1875 to become assistant engineer on location and construction for the Pacific Railway between Selkirk and Rat Portage.

From 1881 to the end of his active career he held numerous responsible appointments on the engineering staff of the Canadian Pacific Railway Company and other Canadian railways.

Mr. Armstrong played an important part in quelling the Riel Rebellion as the man directly in charge of the transportation of troops around Lake Superior at the point where there were gaps in the railway construction.

### Charles Warnock, A.M.E.I.C.

It is with great regret that we announce the death of Charles Warnock, A.M.E.I.C., president of Charles Warnock and Company Limited, Montreal, who passed away on November 4th, 1937, at his residence in Montreal. Mr. Warnock was born at Prince Albert's Landing, now the city of Fort William, Ont., on November 9th 1873.

He was educated at Lake Forest University, Forest, Ill., and subsequently was employed with the Illinois Steel

Charles Warnock, A.M.E.I.C.

Company and other metallurgical firms for a period of eight years. In 1902 he joined the staff of Robert W. Hunt and Company in the United States and in the following year was sent to Montreal as the company's Canadian representative, opening an office for the company in Montreal and becoming manager. He later became vice-president and general manager of Robert W. Hunt and Company Limited and in 1923 he was elected president of this company. In 1926 Mr. Warnock severed his connection with Robert W. Hunt and Company Limited and became president of his own firm under the name of Charles Warnock and Company Limited.

He was elected as an Associate Member of The Institute in 1911.

### Thomas Robert Henderson, M.E.I.C.

The death of Thomas Robert Henderson, M.E.I.C., in Edinburgh, Scotland, in February 1937, will be noted with regret. Born in Montreal, Mr. Henderson received his early education here and attended McGill University. His first engineering appointment was that of rodman on the Ottawa, St. Lawrence and New York Railway in 1885.

During the early part of his career he was connected with the construction of railroads and bridges in Eastern Canada. Mr. Henderson was for a number of years connected with Dobell Coal Company in Western Canada and a greatly esteemed member of the Edmonton Branch of The Institute. He was then residing at Tofield, Alberta.

About 1919 or 1920 he unfortunately suffered severe disabilities as a result of an accident which incapacitated him from doing further engineering work. He went to Scotland to reside in 1927.

Mr. Henderson became an Associate Member in 1892, Member 1905 and Life Member in 1926.

### Rolfe Leigh Doucet, S.E.I.C.

We regret to record the death of Pilot Officer Rolfe Leigh Doucet, R.C.A.F., who was killed in an aeroplane crash, in which three fliers met their death, at Trenton, Ont., on October 19th, 1937. Mr. Doucet was born at Shediac, N.B., June 18th, 1912. He received his education at Acadia University and at the Nova Scotia Technical College, from which he graduated in 1935 with the degree of B.Eng.

In 1935 and 1936 Mr. Doucet was employed by the Milton Hersey Company Limited as an inspector on highways construction in the Maritime Provinces. He obtained his commission as Pilot Officer in the Royal Canadian Air Force last July.

## PERSONALS

H. A. Gibault, A.M.E.I.C., formerly assistant director of Public Works for the City of Montreal, has recently received the appointment of assistant chief engineer for the city.

W. G. MacIntosh, S.E.I.C., has been appointed to the engineering department of the Trans-Canada Air Lines. He graduated from the University of Manitoba in 1936 and prior to accepting his present appointment was a draftsman in the Boeing School of Aeronautics, at the Oakland Airport, California.

M. S. MacGillivray, A.M.E.I.C., is now on the engineering staff of Canadian Industries Limited, Montreal, having left the employ of Messrs. T. Pringle and Sons Limited where he has been since 1929. Mr. MacGillivray is a graduate of Queen's University of the year 1923, after which he took an apprenticeship course with the Canadian Westinghouse Company Limited at Hamilton, Ont. In 1925 and 1926 he was demonstrator in the Electrical Engineering Department of the University of Toronto, and from 1926 to 1929 was assistant electrical superintendent with the Aluminum Company of Canada Limited, Arvida, Que.

C. D. Wight, A.M.E.I.C., until recently assistant roadway engineer and city surveyor for the city of Ottawa, has been appointed assistant waterworks engineer. Mr. Wight graduated from Queen's University in 1928 and was for some time partner in the firm of MacRostie and Wight, consulting engineers, Ottawa.

Leo Roy, Jr.E.I.C., is now sales engineer with the Quebec Power Company in Quebec, having recently been transferred from the Commercial and Distribution Department of the Shawinigan Water and Power Company. Mr. Roy is a graduate of both the Ecole Polytechnique, Montreal, and McGill University, leaving the latter institution in 1932 with the degree of B.Eng. in electrical engineering.

Bruno Grandmont, A.M.E.I.C., until recently district engineer, Department of Public Works, Canada, at Three Rivers, has been appointed to a similar post in Quebec city. Mr. Grandmont, who is councillor for the St. Maurice Valley Branch, graduated from Laval University in 1914. Since that time he has been engaged in engineering work in various capacities in the above department, principally in the vicinity of Three Rivers.

J. H. Landry, A.M.E.I.C., is now district engineer, department of Public Works, with headquarters in Montreal. He for a number of years prior to this appointment assistant to the district engineer in Montreal. He graduated from Laval University in 1913.

A. G. Sabourin, A.M.E.I.C., until recently district engineer with the Department of Public Works, Canada, at Quebec, is now superintending engineer with the department at Ottawa. He graduated from the Ecole Polytechnique, Montreal, in 1902.

J. E. St. Laurent, M.E.I.C., has been made chief engineer, River St. Lawrence Ship Channel, Department of Transport, Montreal. He was previously with the Department of Public Works in Ottawa. Mr. St. Laurent graduated from the Ecole Polytechnique, Montreal, in 1909 and since then has been employed in various capacities throughout Canada with the above department. He was for a time district engineer at Port Arthur and also at Winnipeg. He has been in Ottawa since 1925.

J. B. DeHart, M.E.I.C., has accepted a position with the Provincial Institute of Technology and Art, Calgary, Alberta, where he will be in charge of the coal mining courses. Since 1923 he has been district inspector of mines for the government of the Province of Alberta and located at Lethbridge. Mr. DeHart is a graduate of McGill University in both civil and mining engineering, receiving his M.Sc. in the latter faculty in 1912. Since that time he has had extensive experience in coal mining, having held a number of positions as manager or general superintendent of coal mines between 1914 and 1923.

H. W. B. Swabey, M.E.I.C., has recently been appointed to the staff of the Industrial Investigation Committee, Department of National Defence, Ottawa. He was previously associated with the J. T. Donald and Company and Donald Hunt Limited, Montreal, with whom he had been since 1926. Mr. Swabey received his engineering education at the Crystal Palace Engineering School, London, and his experience since coming to Canada has included that of supervising engineer on the construction of the Atlantic, Quebec and Western Railway, resident engineer for a time on the construction of the Quebec and Western Railway, resident engineer for a time on the construction of the Quebec and Saguenay Railway, and with the Canadian Pacific Railway Company as resident engineer on construction of the Campbellford-Lake Ontario and Western Railway. During the War, as chief inspector of steel, he had charge of the inspection of all steel and forgings for shells manufactured in Canada for the British government.

Brigadier J. L. H. Bogart, R.C.E., D.S.O., A.M.E.I.C., has recently been retired from his appointment as Officer Commanding Military District 13 at Calgary, Alberta, and will reside in Pembroke, Ont. Brigadier Bogart graduated from the Royal Military College with honours in Civil Engineering and in 1897 was appointed to the Reconnaissance Survey of the Militia of Canada. In 1904 he obtained his commission in the Corps of Royal Canadian Engineers, becoming a colonel in 1930. During the War he served in England and France, was awarded a D.S.O. and was mentioned three times in dispatches. In 1918 he acted as staff officer to the C.R.E. Canadian Corps in France and from 1919 to 1923 as senior engineer officer in Military District 2. From 1923 to 1929 he was camp engineer at Petawawa, Ont, and from 1930 to 1934 was director of engineer services, Department of National Defence, Ottawa. From 1934 to 1936 he was again in Petawawa in charge of Department of National Defence relief camps in that area, after which he received the appointment which he is now vacating.

## T. H. Hogg, D.Sc., M.E.I.C.,

**Chairman, Hydro-Electric Power Commission of Ontario**

Dr. Thomas Hogg, M.E.I.C., has been appointed chairman and chief engineer of the Ontario Hydro-Electric Power Commission. Dr. Hogg graduated from the University of Toronto in 1907 after which he accepted a position with the Ontario Power Company at Niagara Falls, resigning in 1911 to become editor of The Canadian Engineer. In 1912 he was appointed assistant hydraulic engineer of the Hydro-Electric Power Commission of Ontario, subsequently being made acting hydraulic engineer and in 1925 chief hydraulic engineer. In 1934 he became acting chief engineer and chief operating engineer, then later chief engineer.

Dr. Hogg has an international reputation as a hydraulic engineer and has been largely responsible for the design for many of the Commission's power plants. He has also

T. H. Hogg, D.Sc., M.E.I.C.

served as consulting engineer for the Dominion and a number of the provincial governments. He represented the Ontario Government in the preparation of the report of the International Joint Commission on the St. Lawrence waterways project and for a number of years past he has been a member of the Lake of the Woods Control Board.

Dr. Hogg has actively participated at meetings of the World Power Conferences and in 1926 presented a paper on "Recent Trends of Water Power Development in Canada" before the Second Conference in Berlin. At the Third World Power Conference in Washington in 1936 he was a member of the Canadian National Committee and also an official Canadian delegate.

Dr. Hogg received the honorary degree of Doctor of Engineering from the University of Toronto in 1927.

## ELECTIONS AND TRANSFERS

At the meeting of Council held on November 19th, 1937, the following elections and transfer were effected:

*Juniors*

*CHAREST, Pierre Antoine, dftsman., Fraser Companies Limited, Edmundston, N.B.

*HOVEY, Charles Mansur, (Univ. of Man.), laboratory technician, civil and mechanical engrg. depts., University of Manitoba, Winnipeg, Man.

*Transferred from the class of Junior to Associate Member*

RUSSELL, John Arthur, chief engr., Dominion Coal Company Limited, Sydney, N.S.

*Students Admitted*

COURTNEY, Ernest Cleveland, B.A.Sc., (Univ. of B.C.), 3637 Oxenden Ave., Montreal, Que.

DeMAIO, Alexander, B.A.Sc., (Univ. of Toronto), 149 Rubidge St., Peterborough, Ont.

FINDLAY, Allan Cameron, ap'tice dftsman., Dominion Bridge Co. Ltd., Montreal, Que.

FROMSON, Sam, (McGill Univ.), 524 Prince Arthur St. W., Montreal, Que.

GODDARD, Albert Reginald, (Univ. of Man.), 696 Strathcona St., Winnipeg, Man.

HARVEY, Ernest Allen, B.Sc. (Univ. of Sask.), (Univ. of Man.), 379 Broadway Ave., Winnipeg, Man.

KORCHESKI, William B., (Univ. of Man.), 460 Kennedy St., Winnipeg, Man.

LEMAISTRE, Edward Benjamin Aycrigge, (McGill Univ.), Central Y.M.C.A., Montreal, Que.

MORRISON, John Davis, (McGill Univ.), 68 Bruce Ave., Westmount, Que.

NORTHOVER, Arthur B. Clinton, B.A.Sc. (Univ. of Toronto), Cawesco Club, Hamilton, Ont.

PALMER, Kenneth Winfield, B.Sc. (Metal.), (Univ. of Birmingham), 1321 Sherbrooke St. W., Montreal, Que.

PHOMIN, Barney Louis, (Univ. of Man.), 395 Union Ave., Winnipeg, Man.

WILLIAMS, Donald D., (McGill Univ.), 359 Laurier Ave. W., Montreal, Que.

**Students at the Ecole Polytechnique, Montreal, Que.**

ASSELIN, Hector, 118 Maplewood Ave., Outremont, Que.
BEIQUE, Freddy Paul, 550 Davaar Ave., Outremont, Que.
BERNIER, Hubert, 3695 St. Andre St., Montreal, Que.
CHADILLON, Francois, 2343 St. Antoine St., Montreal, Que.
COUPIENNE, Gilbert, 2091 Union Ave., Montreal, Que.
FRIGON, Raymond A., 125 Pagnuelo Ave., Outremont, Que.
HALLE, Paul, 1470 Ontario St. East, Montreal, Que.
HAMELIN, Roger, 7609 de Gaspe, Montreal, Que.
LACROIX, Jean, 1785 Van Horne Ave., Outremont, Que.
LALONDE, Jean A., 958 Dunlop Avenue, Outremont, Que.
LAMARCHE, Marcel, 1891 Sherbrooke St. East, Montreal, Que.
LECAVALIER, Fernand, 6280 St. Denis St., Montreal, Que.
LEROUX, Jacques Pierre, 3686 St. Hubert St., Montreal, Que.
L'HOMME, Louis Philippe, 50 Yamaska Ave., Farnham, Que.
MARCHAND, Fernand, 8202 St. Denis St., Montreal, Que.
MARTEL, Pierre, 2006 St. Denis St., Montreal, Que.
MENARD, Raymond, 2035 Rachel St., Montreal, Que.
O'DONOUGHUE, Gerald, 4209 Drolet Street, Montreal, Que.
PARE, Joseph Leandre, 201 Sherbrooke St. East, Montreal, Que.
VAILLANCOURT, Jean Louis, 3225 Lacombe Ave., Montreal, Que.

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*Has passed The Institute's examinations.

### Errata

The following corrections should be made in the text of the paper "The Beet Sugar Factory at Picture Butte, Alberta" by F. H. Ballou, published in the November number of The Journal, pages 802-806:—

Page 805—first column—lines 42-44—should read "*Pumps:* The plant is equipped with 62 centrifugal pumps of which 35 operate at 3,500 r.p.m. No reciprocating pumps are used."

Page 806—second column—Omit last two paragraphs substituting the following paragraphs:

The total production of Alberta sugar from the sugar beet crop of 1936 was 652,996 one hundred pound bags.

The latest figures on yearly consumption in Alberta show about 620,000 one hundred pound bags of which Alberta sugar supplied in 1936 around 290,000 one hundred pound bags or less than 50 per cent. In the city and district around Calgary, sales of Alberta sugar reach over 70 per cent, but a large proportion of Alberta grown sugar must be sold elsewhere than in Alberta.

The beet sugar industry of Alberta has supplied producing capacity, to furnish all the sugar required in Alberta. Estimates for 1937 crop are over 700,000 one hundred pound bags.

## Addresses Wanted

Any information regarding the following members for whom we are without addresses, would be much appreciated:—

Members
*A. H. Blanchard*
*J. Hardy Devey*
*C. P. Dunn*
*Harry Kay*
*Geo. Scott*

Associate Members
*John G. M. Baxter*
*H. R. Bissell*
*Chas. K. Brown*
*D. L. Carr*
*G. P. Castleden*
*F. A. Crawley*
*S. A. Desmueles*
*Wm. H. Hunter*
*L. E. Kendall*
*T. M. Montague*
*John Paris*
*L. A. Perry*
*M. F. O'Day*
*G. C. Perkins*
*F. J. Robertson*
*C. H. Silcox*
*J. C. K. Stuart*
*C. J. Swift*
*H. M. Thompson*
*M. Tison*

Juniors
*T. E. Dwyer*
*W. L. Foss*
*L. C. Gonzalez*
*Wilfrid J. Grant*
*J. E. Hawkins*
*F. H. Job*
*M. Lamoureux*
*H. A. Merton*
*F. Stewart Morgan*
*Walter A. Smith*

Students
*R. E. Bates*
*Alan C. Brown*
*D. W. Brown*
*F. E. Crowe*
*G. G. DeMocko*
*E. W. Donohue*
*J. K. Flexman*
*J. M. Garden*
*B. J. Hawkey*
*A. Hopkins*
*Walter Houghton*
*A. S. Marshall*
*L. J. Marshall*
*W. O. Richmond*
*W. M. Robinson*

## CORRESPONDENCE

The Editor,
The Engineering Journal.

Dear Sir:—

In his paper, "The Fatigue of Metals,"* Dr. Farnham has attempted, quite successfully, to give a very brief survey of what is known to date concerning the fatigue type of failure of metals. The writer agrees with the author that "progressive failure" is the proper term to be used in describing the type of failure under discussion, though "creeping fracture" might also be employed. He cannot agree, however, that the term "fatigue failure" should continue to be used as synonymous with "progressive failure," for the latter term describes the process by which failure takes place, whereas the former refers to the process by which the initiation of the fracture, which subsequently develops by the progressive process, occurs. Progressive failures may occur which are not initiated by the fatigue process, if one limits the concept of fatigue as being directly and uniquely related to cyclic stressing. In a sense, all fractures are progressive. Cyclic stressing produces a slowly progressing fracture—on the other hand, static stresses produce a rapidly progressing fracture and there are certain cases which lie between these extremes.

Attention should be especially directed to the author's statement concerning the failure of metals due to "crystallization in service." It has been known for a long time that no such process can occur in metals at temperatures below their respective critical ranges but it is remarkable how this false notion has persisted so long in the engineering mind. Anything which can be done to eliminate this erroneous idea is worthy of commendation.

Too much emphasis cannot be placed on the value of Dr. Gough's important work in which he has shown for the first time that failure of metals initiated by fatigue is identical, macroscopically at least, with that initiated by static stressing. That is to say, the mechanism by which the crystal grains break up initially is the same in all cases so far observed regardless of the type of stressing. These changes have been described by Dr. Gough as a "dislocation of the initially perfect grains into large components...", with the subsequent formation of crystallites, i.e., small submicroscopic blocks of crystal having a definite lower limit as to size. This process is accompanied by internal stressing of these fragments. The full impact of these important discoveries is only just beginning to be felt in the field of the science of metals.

The photograph, Fig. 1, illustrates a fracture of a plain carbon steel street-car axle. All of the features on the photograph show the fracture to be of the progressive type. The writer does not believe this to be a fatigue failure, however, for the following reasons: The stresses on the metal were not particularly high even when the car was under full load. From the records of distance travelled by the car, it was estimated that the number of stress cycles was of the order of $300 \times 10^6$. The fracture became complete a few days after a period of very low atmospheric temperatures and records show that failures of axles seldom occur in the warm weather. It seems probable that the correct explanation of such failures—without going into a detailed discussion—is that small cracks are started by impact during the period of low temperature of the metal and while the frogs in the track are rigidly held in frozen ground. Once started, the progressive failure develops in precisely the same manner as if the initial cracking had been produced by fatigue stressing. The result is the same in both cases. The cause, however, is different.

**Fig. 1—Low Temperature fracture in a street car axle.**

I. F. Morrison,
Professor of Applied Mechanics,
University of Alberta.

Edmonton, Alta.
November 26th, 1937.

*Published in The Engineering Journal, November 1937.

## BULLETINS

*Tractors.*—A 24-page bulletin by the Caterpillar Tractor Company Peoria, Ill., deals with the adoption of Diesel power for highway construction and maintenance equipment. Various types of equipment are illustrated in operation throughout the United States.

*Pumps.*—A 6-page leaflet by the Roots-Connersville Blower Corporation, Connersville, Ind., gives details of their automatic boiler service units and the sizes in which they are manufactured. These units are particularly adaptable for all plants using steam for processing.

*Snow Ploughs.*—The Cleveland Tractor Company have published a group of 4 leaflets illustrating their snow removal equipment including snow ploughs and bulldozer combinations.

*Insulating Materials.*—Insulating products of the Canadian Johns-Manville Company, Montreal, are described in a 64-page booklet recently received and covers among other things roofs, floors, friction and insulating materials generally, also packings, gaskets, refactory cement and transite.

*Time Switches.*—The Canadian General Electric Company, in an 8-page bulletin, give details of their general purpose automatic time switch, type T-17.

*Jaw Crushers.*—A 12-page pamphlet received from the Dominion Engineering Company, Montreal, describe their jaw crushers, a complete range from 10 by 20 in. to 48 by 72 in. in 9 standard sizes.

*Air Filter.*—A 4-page circular from the Northern Blower Company, Cleveland, Ohio, describes their Norblow, a square type air filter for automatic and continuous service.

*Monel, Nickel and Inconel.*—The International Nickel Company, in a 28-page booklet, list 400 practical applications for monel, nickel and inconel, under corrosive conditions, tabulating data of definitely established uses of these materials in a concise form.

## Index to Volume XX

The Index to Volume XX of The Engineering Journal, covering the twelve issues, January to December 1937, appears in the back of this number of the Journal.

This has been made as complete as possible in the space available and all articles and important items have been included.

In many cases references appear under two or more headings in order to facilitate any search for information.

# RECENT ADDITIONS TO THE LIBRARY

### Proceedings, Transactions, etc.

Mysore Engineers Association, Bangalore, India: Bulletin for Oct. 1936 to June 1937. Vol 14, No. 4; Vol. 15, Nos. 1 and 2.

The Institution of Naval Architects: Transactions, Vol. 79, 1937.

The Royal Swedish Institute for Engineering Research: Tool-life and Balance of Heat in Lathe Work by Ragnar Woxen; X-Ray and Microscopic Studies on the Nitrided Layer in Nitriding Steels by Gunnar Hagg; Is the Second Law of Thermodynamics Generally Valid for Macroscopic Processes? by A. Lindblad and R. Liljeblad; Proceedings No. 142-45, 1937.

Smithsonian Institution: Annual Report 1936.

### Reports, etc.

*American Society for Testing Materials:* A.S.T.M. Tentative Standards 1937.

*American Society of Civil Engineers:* Practical Application of Soil Mechanics, A Symposium, 1937.

*American Waterworks Association, Canadian Section:* Waterworks Information Exchange, Volume 1, 1936.

*Canada, Department of Labour:* Report for the Fiscal Year Ending March 31, 1937.

Twenty-Sixth Annual Report on Labour Organization in Canada for the Calendar Year 1936.

*Canada, Department of Mines and Resources:* Geodetic Service Publication No. 61: Triangulation in Northern Quebec by J. E. R. Ross.

*Canada, Department of Mines and Resources, Mines and Geology Branch; Bureau of Mines:* Investigations in Ore Dressing and Metallurgy, January to June 1936 (No. 774); July to December 1936 (No. 776).

*Canada, Department of Mines and Resources, Mines and Geology Branch, Geology Survey:* General Geology and Petroleum Resources of Manitoulin and Adjacent Islands, Ontario, by M. Y. Williams. Nelson Map-Area, British Columbia by H. M. A. Rice.

*Canada, Dominion Bureau of Statistics, External Trade Branch:* Summary of the Trade of Canada, August 1937 and 12 Months Ending August 1936 and 1937.

*Canada, Dominion Bureau of Statistics, Transportation Branch:* Statistics of Steam Railways in Canada 1936.

*Edison Electric Institute, Prime Movers Committee:* Oil and Gas Engines 1936-37.

*Engineers' and Road Superintendents' Conference:* Road and Highway Drainage by D. J. Emrey. Toronto, Feb. 22, 1937. (National Sewer Pipe Company, Limited, Toronto.)

*Federation of British Industries:* Fuel Economy Review, 1937.

*National Research Council of Japan:* Report of Radio Research in Japan, 1937.

*North-East Coast Institution of Engineers and Shipbuilders:* Presidential Address by Prof. C. J. Hawkes, M.Sc.; Report of the Council, 1936-37.

*Quebec Department of Municipal Affairs, Trade and Commerce:* Bulletin Meteorologique, May, June, July, August 1937.

*Rensselaer Polytechnic Institute:* Bulletin, Solution of the Elastic Curve Equation, $M = EI \frac{d^2y}{dx^2}$ by H. B. Compton and C. O. Dohrenwend. 1937.

*U.S. Department of the Interior, Bureau of Mines:* Bulletin 404, Burning of Coal and Coke Treated with Small Quantities of Chemicals. Technical Paper 574, Analyses of Colorado Coals.

*U.S. Department of the Interior, Geological Survey:*

Bulletin 872, The Yukon-Tanana Region Alaska.

Water-Supply Paper 679-B, Thermal Springs in the United States; 796-D, Geology and Ground-Water Resources of Ogden Valley, Utah; 796-E, Ground Water in Avra-Altar Valley, Arizona; 798, The Floods of March 1936, Pt. 1 New England Rivers; 807 and 814, Surface Water Supply of the United States 1936, Pt. 7, Lower Mississippi River Basin, Pt. 14, Pacific Slope Basins in Oregon and Lower Columbia River Basins; 817, Water Levels and Artesian Pressure in Observation Wells in the United States in 1936; 819, The Warm Springs of Georgia, Their Geologic Relations and Origins.

*University of Illinois:* Bulletin No. 296, Magnitude and Frequency of Floods on Illinois Streams by G. W. Pickels.

### Technical Books, etc.

Industrial Marketing 1938 Market Data Book Number. (*Advertising Publications Inc., Chicago, Ill.*)

Theory of Statically Indeterminate Structures by W. M. Fife and J. B. Eilbur, 1937. (*McGraw-Hill, New York.*)

## New Zealand Institution of Engineers

At a special general meeting on September 15th, 1937, in Wellington, the rules of the New Zealand Society of Civil Engineers were amended so as to change the name of this Society to the New Zealand Institution of Engineers.

This step is of interest to members of The Institute as it may be remembered that the Canadian Society of Civil Engineers took a similar step in 1918 in changing the name of our Society to The Engineering Institute of Canada.

# BOOK REVIEW

## The Motor Truck in Woods Operation

*By C. R. Townsend, Woodlands Section, Canadian Pulp and Paper Association, Montreal, 1937. 82 pp. 9 by 12 inches.*

Reviewed by J. B. D'Aeth, M.E.I.C.*

This book is based upon the findings of Mr. C. R. Townsend, who was employed by the Woodlands Section of the Canadian Pulp and Paper Association to investigate the use of motor trucks for the transportation of logs in Canadian woods operations. Mr. Townsend had previously had extensive experience in woods operations with the Consolidated Paper Corporation.

The publication is the result of ten months of study and investigation of the subject, which is comparatively new and to a great extent in the experimental stage.

The book is divided into two parts. Part one covers the different phases of a woods operation such as:

The methods employed in the pre-haul or the delivery of logs to the main truck road from the stump.

Methods of loading trucks or sleighs; also tables showing various rates of loading in cords per man hour.

Types of winter truck roads with description of methods and equipment required for making and maintaining same.

The different types of hauling equipment used, such as trucks, trucks with semi-trailer, and trucks hauling sleighs. A table is given showing the Provincial truck regulations governing the length, width, height, and loading of trucks for each province.

Methods and arrangements for unloading wood.

There is a list of 13 typical woods trucking operations with partial hauling costs. These operations are well described and the basic data given for each case. Twenty-two diagrams and three hundred and thirty-six small photographs are used to illustrate the descriptions and show details of the various phases of the work described.

Part two covers the theory and mechanics of the haulage equipment and covers such questions as:

Truck power and the relationship of gear ratios. This becomes extremely important when the truck is acting as a haulage unit for a train of sleighs.

Sliding resistance of sleighs, and some interesting experiments conducted by the author to show the advantage of water lubrication on iced or snow roads immediately preceding the passage of loaded sleighs.

The author presents results of experiments to show that rubber does not follow the ordinarilly accepted laws pertaining to the coefficient of friction as follows:—

That the coefficient of friction in the case of rubber increases with the area in contact, that it increases with the load applied, that it increases with velocity at low velocities, and that the kinetic value is greater than the static.

Rolling resistance is discussed in relationship to road surfaces and tire chains.

Diagrams and formulae are given to show the effect of sleighs attached to trucks and the resulting distribution of load on the front and rear axles of the truck.

There is a good discussion on truck tires, and the question of overloading them, also the proper use of chains.

Discussion of grades and curves and the necessity of grade compensation when they occur together.

As far as the reviewer is aware, this is the first time that such extensive data on the subject has been collected and made available in a unified form. To anyone interested in the transportation of logs or winter truck freighting this book should prove extremely valuable.

* *Engineer, Fraser, Brace Company Limited, Montreal.*

# The Profession's Current Problems

*An address, by Willard Chevalier**

*Vice-President of the McGraw-Hill Publishing Co., New York.*

**(Abridged from a report in the Engineering News-Record, November 18, 1937)**

This word "profession" is bandied about very glibly but there are not many people who will agree on a clear-cut and convincing definition of what the term means.

Does it mean any calling that, in the public interest, is closed by a statute to all except those duly licensed to practise it? Does that make a professional man of a barber or a bar-keeper? Obviously our conception of a profession and a professional man cannot be expressed accurately by a term that is used so loosely; neither can we create the profession that we have in mind merely by the enactment of a statute or the technical definition of a term.

Even in medicine and law, with all their statutory regulation, the public still must rely in large measure upon the moral influence of a professional spirit to make this thing effective and make it work. In other words, the point I am trying to make is that there is something bigger, more vital, and more fundamental in a professional relationship than anything you can write into a statute.

Unless we have in the profession of engineering some vital influence above and beyond the mere statute itself, it will be but a question of time before those of minimum technical qualifications will demand and be accorded the right to practise, regardless of what you and I may think of their other professional qualifications.

And these other qualifications are of the very essence of what I understand to be a profession. Certainly they mean a great deal in law and medicine. Why? Because of the confidential relationships with uninformed laymen who are not in a position to protect themselves or guard themselves against the charlatan. Shall we be able to maintain and enforce similar standards in the case of the engineer, or shall we be forced to rule those out? Are we in danger of facing a ruling one of these days that any one who can meet the minimum technical requirements has the right to be licensed and practise his calling? That is when we shall find out whether we have a profession or just another licensed trade.

When we start drawing this analogy between the engineer and the doctor and the lawyer, we find another false note. We find that it is the intent and the ambition of the young doctor and the young lawyer sooner or later to go into practice for themselves. They may for a time work for someone else; they may be a part of a professional organization as subordinates. But either they are going to become partners in a firm or they are going to have their own practice. That is true of the bulk of them. It is not true of the great bulk of young engineers who must look forward—and I say this in no invidious sense—to being employees on someone's payroll—that of the public, some corporation, or an individual.

You will have a very great difference in the ultimate responsibilities of the men who call themselves engineers by virtue of a definition in a statute or on a diploma. One man may have almost no ultimate technical responsibility. He is hired by other engineers who take full professional responsibility for his work, and his ultimate client—the layman—may never know of his existence. Let us face that fact.

On the other hand, we have at the top men who will carry the ultimate technical responsibility to their clients. The chief engineer of a railroad, the consulting engineer for a city, the chief engineer of an industrial plant or a city department who reports to a lay board of directors or a lay city council—that man must take the ultimate technical responsibility for his decisions. There is no technical man above him who will modify his decisions or take responsibility for his failures. There is an *ultimate technical responsibility* and to me it is that relationship which constitutes the core of a professional relationship.

Many of these engineers who have no ultimate responsibility always will regard the other engineers, not as their professional brethren, but as their bosses. A very eminent engineer once told me that he considered it a definite part of his responsibility to his employer to hire his staff on the lowest terms consistent with competent service. This instance, although not typical, shows that we have a very definite problem in the relation between employer-engineer and employee-engineer, *insofar as their current relationship* is concerned.

We thus have the employer and employee relationship among engineers, all of whom have the same words on their diploma, all of whom can qualify under the same statutes. That is another reason why I do not believe that we ever are going to solve these problems by statutes alone. That is why I believe that the several professional engineering societies today have an even broader field of usefulness and a more important function to perform than they ever had before the statutory licensing of engineers. If we are going to give spiritual effect to the bare flesh and bones of our engineering legislation, we must have these professional societies which, entirely apart from statutory requirements, will take into account everything else about a man in addition to his educational and technical attainments.

That is the reason why I do not want to see any formal relationship between these two. I do not want to see our long-established professional bodies made tails to any statutory kite, neither do I want to see those societies involved in the operation of a licensing statute. The national engineering society's function today has become even more vital than before. It is they, with their tradition of disinterested and voluntary association for purely professional concerns, who must be in a position to establish and enforce those standards of professional responsibility and ethics that cannot be written into a statute.

Therefore, I hope that our professional societies, both old and new, will recognize today their responsibility for the less sharply definable concepts of what constitutes a profession and that they will guard them more closely than ever before.

What shall we say to the employed engineer when he asks, "Shall I join the union or not?" I would say: "My boy, you have your own way to make in the world. You must earn the best living that your energy, skill and intelligence will make available to you. You are carving out your own career, so make up your own mind. When you have done so, go the way you have chosen without complaint, if it does not work out the way you expected. If you are primarily interested in what a labour union offers, if you want to cast in your lot with organized labour, that course is open to you."

On the other hand, if you feel that there is something of real value in what we call the engineering profession, the chances are that the labour union will not give you what you want. You have a right to make your own decisions as to what road you will take, but when a certain point is passed there can be no turning back.

I have great sympathy for the young men who are being paid less than the mechanics with whom they must work every day. There are many thousands of these young men, who never will have the opportunity to do any more responsible work than they are doing. They will acquire experience but will remain employee-engineers, responsible to some employer-engineer. To such men, who know they are close to the limit of their earning capacity, there is little use of talk of professional future. If they are to remain at that kind of work and are willing to cast their lot in with that of the manual worker, why should the professional engineers try to take them in?

Probably out of all this will come a natural separation. Some individuals will align themselves with labour organizations. They will consider the material interests of today. If they have any professional heritage, they will be willing to sell it for the pottage of immediate benefits. If they decide that that is the road that they want to follow, they have a perfect right to follow it, just as does any craftsman who organizes to better his condition.

On the other hand, if the professional group makes the profession seem worthwhile and stimulates these men's interest in things not concerned exclusively with material interests, many will follow the professional standard and later will fill positions of responsibility in the profession.

The destiny of the engineering profession cannot be shaped by legislation, nor can the problems of engineering employment be solved by denouncing this movement or that organization. Regardless of present difficulties, the long term welfare of the profession and its members will be worked out by individuals, each pursuing a course which seems to him to be sound.

The instruments that must be used to shape our profession include the work of the engineering examiners, the professional engineering societies and the engineering schools. Through all of these it is possible to create a profession that will measure up to its responsibilities. Each of these contributes its part: technical and intellectual fitness, a professional conscience that assumes a responsibility to the community for the standards of its members, an attitude toward the day's work that is distinct from that of the time-server, and the power of the state to safeguard the people against injury at the hands of the unworthy..

Let us then organize our societies and enact our statutes; let us organize our schools to educate the young men on the threshold of the profession and let us do our best to establish working conditions that will recognize sound relationships between employers and employed. Let us do all we can to inform these young men as to what a profession is, what it stands for, and what it offers to them in return for what it demands.

*Before the National Council of State Boards of Engineering Examiners at their annual meeting in Scranton, October 11-13, 1937.

## World Power Conference

By invitation of the Austrian National Committee, a sectional meeting of the World Power Conference will be held in Vienna from August 25 to September 2, 1938. The meeting will deal with "The Supply of Energy for Agriculture, Small-Scale Industries, Household Purposes, Public Lighting, and Electric Railways." The technical programme of the Conference, which has just been published from the offices of the Weltkraftkonferenz, Teiltagung Wien, 1938, Lothringerstrasse, 20 (Konzerthaus), Wien, III, Austria, is accordingly arranged in five sections, and it is emphasized that, within each of these sections, the question of the energy requirements should be dealt with solely from the point of view of the consumer. Apart from the last section relating to electric railways, the scope of the first four sections is to cover all forms of energy available and in actual use, including solid and liquid fuels, gas, water power, wind power, steam, electricity, and human and animal drives. In order to allow sufficient time for the printing and distribution of the papers and general reports, the Austrian National Committee requests that papers be in their hands not later than March 1, 1938.—*Engineering.*

## Discussion on Lubrication and Lubricants

The Institution of Mechanical Engineers with the co-operation of other Societies and Institutions held a general discussion on lubrication and lubricants from October 13th to 15th, 1937. At this meeting a series of some 100 papers were presented by leading authorities throughout the world. An exhibition was held in connection with this meeting. The papers presented were grouped under four heads: 1. Journal and thrust bearings, including general and practical aspects, bearing materials, tilting-pad bearings and collar and related types. 2. Engine lubrication for internal combustion and reciprocating steam engines. 3. Industrial applications, including lubrication of anti-friction bearings and gear lubrication. 4. Properties and testing.

Bound volumes of these proceedings may be obtained from the Institution.

## Symposium on Propellers

North East Coast Institution of Engineers and Shipbuilders, Newcastle upon Tyne, announce a "Symposium on Propellers" which is to take place on March 31st and April 1st next. The authors are almost entirely outstanding tank experimenters in connection with the design of propellers in England and on the continent. There will possibly be additional papers later. It is hoped by bringing together so many of the leading tank experimenters dealing with subjects upon which each is a specialist that up-to-date information valuable to engineers and naval architects will be provided by the symposium, and that the discussion on the papers may, on the other hand, be helpful to the experimenters represented by the authors. A list of the papers follows:—

- "Qualities Required in Propellers," by Dr. G. S. Baker, O.B.E., Honorary Fellow, Superintendent of the William Froude Laboratory.
- "Measurement of Wake," by Prof. Dr. Ing. F. G. A. Horn, Technische Hochschule, Charlottenburg.
- "Aerofoil Sections and Their Adoption in Propeller Design," by James F. Allan, B.Sc., Experiment Tank, Messrs. Wm. Denny and Bros. Limited.
- "Open-Water Test Series with Modern Propeller Forms," by Ir. L. Troost, Member, Superintendent, Experiment Tank, Wageningen, Holland.
- "Effect of Rough Water on the Performance of Propellers," by J. L. Kent, the William Froude Laboratory.
- "Immersion of Propellers," by Dr. Ing. G. Kempf, Director of Hamburg Tank.
- "Effect of Shaft Brackets on Propeller Performance," by R. W. L. Gawn, R.C.N.C., of Admiralty Experiment Works, Haslar.
- "Propellers for Tug-Boats," by Frank W. Benson, Member, Scotts' Shipbuilding and Engineering Company.
- 'Experiments on the Optimum Diameter of Propellers of Single-screw Ships," by Dr. Masao Yamagata, Director, Teishinsho Experiment Tank, Tokyo.
- "Torsion and Torsional Oscillation of Blades," by Dr. W. J. Duncan.

## November Journals Required

Copies of the November, 1937, issue of The Engineering Journal are required for binding, and it would be appreciated if members having no further use for this issue would forward copies available to Headquarters at 2050 Mansfield Street, Montreal.

## Memorial Sun-Dial to the late W. J. Cunningham, A.M.E.I.C.*

A feature of the President's visit to Edmonton on August 28th, 1937, on his recent tour of the Western Branches was a ceremony which took place at the City Power Plant, and at which he presided. This ceremony was the unveiling and dedicating of a sun-dial to the memory of W. J. Cunningham, A.M.E.I.C., for some years preceding his death superintendent of Edmonton's power plant.

Mr. Cunningham's untimely passing in 1934 was a matter of such regret to his many friends that the idea was conceived of preserving his memory in a material way. A memorial sun-dial was decided upon as the means of doing this and a committee was formed with A. W. Haddow, M.E.I.C., Edmonton's City Engineer, as chairman, to carry out the plan.

A site for the memorial was provided by the city in front of the power plant office. The city also bore the expense of constructing the foundation and of beautifying with lawns and flowers beds the area thus set aside. The monument itself was paid for from contributions by Mr. Cunningham's personal friends in the engineering profession in various parts of Canada.

The sun-dial was designed by Prof. Burgess of the University of Alberta and consists of a Tyndall stone shaft surmounted by a brass dial bearing the inscription. Also affixed to the shaft is a small brass plate bearing suitable symbols and so placed by the Wardens of Camp VI, "The Ritual of the Calling of an Engineer."

Others taking part in the ceremony who spoke briefly or placed sprays of flowers on the memorial besides President Desbarats and Mr. Haddow, were J. D. Baker, M.E.I.C., for the Wardens of Camp VI, C. E. Garnett, M.E.I.C., for the Association of Professional Engineers of Alberta, R. G. Watson, A.M.E.I.C., for the power station staff and Mayor Clarke, who assumed permanent custody of the memorial on behalf of the City of Edmonton.

The eulogistic nature of the references to the late Mr. Cunningham were significant as to the calibre of the man and significant too were the simple but impressive words on the dial of the dignified little monument.

**William John Cunningham**

**Superintendent of Edmonton City Power Plant, 1920-1934, intended to place a sun-dial on this spot. In respect for his devotion to duty and for his desire to create beauty around him, his friends now fulfil this intention.**

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*Submitted by F. A. Brownie, Jr.E.I.C., Edmonton Branch News Editor.

## Second Symposium on Water Hammer

A Second Symposium on Water Hammer is being held under the auspices of the American Society of Mechanical Engineers in New York on December 8th and 9th, 1937. Signor Lorenzo Allievi has been appointed Honorary Chairman, and the American Society of Mechanical Engineers is to confer an Honorary Membership in the Society on him on that occasion in recognition of his contributions to the advancement of knowledge on the subject.

The Engineering Institute of Canada will be represented by a number of members including Messrs. Norman R. Gibson, M.E.I.C., S. Logan Kerr, M.E.I.C., Professor Robert W. Angus, Hon.M.E.I.C., and Professor F. M. Wood, A.M.E.I.C.

# BRANCH NEWS

## Border Cities Branch

*J. F. Bridge, A.M.E.I.C., Secretary-Treasurer.*
*F. J. Ryder, Jr. E.I.C., Branch News Editor.*

The first dinner meeting of this Branch for the 1937-38 season was held at the Prince Edward hotel, Friday evening, October 15th. There were thirty-seven persons present to hear and see sound pictures on "Heat Insulation." Mr. William G. Bright, of the Canadian Johns-Manville Company Limited, discussed the paper as presented by the sound reels and answered questions.

### Heat Insulation

Heat is nature's most powerful force and without heat man cannot live. Heat is defined as molecular motion. Various scientists have discarded old theories and promulgated new ones as more and more has been learned about heat and its actions. Heat being a form of energy follows the law of conservation of energy, namely, "That energy can neither be created or destroyed. Any type of energy can be transformed into any other type of energy." There are three methods of transferring heat which are: convection, conduction and radiation. A popular belief in the so-called "dead-air space," which is supposed to insulate our homes, has been proven a fallacy as the moving picture camera has been able to photograph convection currents set up in "dead-air space" due to differences of inside and outside temperatures.

After discussing the theory of heat and the problems presented in order to conserve it, the methods that the Canadian Johns-Manville Company used in their laboratories to provide the best means of controlling and overcoming these problems were outlined.

Mr. Krebser thanked the speaker on behalf of the Branch.

## Calgary Branch

*James McMillan A.M.E.I.C., Secretary-Treasurer.*

The Branch started the new season's activities by staging the annual golf tournament at Strathmore on the finest afternoon experienced this September. The enjoyment of the afternoon was greatly enhanced by the hospitality extended by Mr. and Mrs. G. H. Patrick to those who took part in the outing.

### The World Oil Situation

On the evening of September 17th, the first technical address of the season was presented by Dr. G. S. Hume, Dominion Government Geologist, on "The World Oil Situation." He began by describing the potential and producing oil fields of the United States in which 60 per cent of the world production is centred. The East Texas field, the world's largest, has wells which produce as much as 12,000 barrels per day. From a peak production of 750,000 barrels per day in 1933 the production has been reduced to 450,000 barrels by means of proration. The ultimate surface yield of this field is estimated at four and one-half billion barrels. The greatest reserve in the United States is in the State of Kansas where 54 new fields were discovered last year. Approximately only 10 per cent of the country's potential production is now being taken due to market conditions. The Near East fields are next in importance to those in the United States due to their proximity to the great oil consuming countries of the world. The most important of these are in Baku, Irak and Iran. In Germany, France, Italy, Japan and Britain hydrogenation of coal and oil shales is becoming a serious competitor of crude oil as a source of fuel. Dr. Hume drew attention to the ever increasing importance of fuel oil as opposed to gasoline in domestic, industrial, commercial and shipping operations.

### Dinner Meeting

At the meeting on October 20th, the members of the Branch were entertained as guests of the Canadian Western Natural Gas, Light, Heat, and Power Co. Ltd. at an informal dinner in the company's new demonstration auditorium. Following the dinner Mr. E. W. Bowness showed a series of motion pictures of his trip to Europe, which included scenes of the coronation and gave his impressions of the political and economic situation in each country which he visited.

## Hamilton Branch

*A. R. Hannaford, A.M.E.I.C., Secretary-Treasurer.*
*W. W. Preston, S.E.I.C., Branch News Editor.*

The opening Fall meeting of the Branch, held October 5th, 1937, in McMaster University, will stand out in the members' minds for a long time. Following an informal dinner in McMaster Refectory, the distinguished visitor, Major-General A. G. L. McNaughton, C.B., C.M.G., D.S.O., LL.D., President of the National Research Council, Ottawa, and formerly Chief of Staff for the Department of National Defence, addressed an audience of 97. General McNaughton, who was introduced by his one time class mate, Major H. A. Lumsden, M.E.I.C., spoke on "The Work of the National Research Council."

### The National Research Council

The speaker drew an analogy from the present rearmament race in Britain to warn industrialists of the dangers in skimping research development. Just as the pending international crisis has spurred Britain to rearm suddenly at great cost to the taxpayers for generations to come, so, sooner or later, perils may affront Canadian industry both in our own and the markets of the world compelling enormous sums to be spent on research in a short period. A considerable proportion of Britain's expenditure could have been avoided if those who held the purse strings in the years since the war could have been persuaded to allow research, experiment and development, as the army authorities wished, at a moderate rate. The speaker believed that industrial research is not being carried out in Canada on a scale needed for adequate protection, and pleaded that industry gradually expand its research activities and avoid possible crises.

The work of the National Research Council is conducted in aid of industry and on request. The Council endeavours to provide information through its accumulation of technical literature, by precise measurements, by co-operative measures with outside sources and through collections in its museums. Beneficiaries and not the state are the Council's chief source of revenue.

The accuracy of results obtained in these laboratories must be superior to the results of other investigators in Canada and must agree with the results obtained at foreign laboratories.

Giving brief descriptions with lantern views, General McNaughton outlined the facilities of the laboratories and their work, citing numerous examples.

Several achievements of the Council have not previously been made public because patents had not been granted, but device has been designed to aid aeroplane pilots trace forest fires to their source by means of sound; and a windmill has been perfected to enable farmers to charge radio batteries. Weather forecasting by the use of cathode ray direction finders is being developed so that operators at distant points can synchronize their apparatus at a given signal, and by a system of triangulation and co-relation of meteorological information will, it is hoped, be able to forcast the weather with a greater degree of accuracy than is done at present.

In an attempt to solve the problem of transporting perishable foods to Britain, physicists and biologists are working on a new system of refrigeration where it will be possible to control humidity at forty degrees below zero.

A rust resisting wheat will be ready for the Western farmers next spring and work is progressing on a new type of barley for the use of British maltsters.

Colonel E. G. MacKay, Chairman of the Hamilton Branch, presided at the dinner and also at the Professional meeting.

The vote of thanks, which was very heartily endorsed by all present, was proposed by W. Hollingworth, M.E.I.C., and seconded by E. T. Sterne.

Chancellor Whidden and Dr. Burke of McMaster University were present at the dinner and meeting and spoke to the gathering.

After the lecture an enjoyable half-hour was spent while refreshments were served to all.

### Recent Achievements in Colour Photography

On October 21st, Mr. Herbert Johnson, of the Eastman Kodak Company Rochester, N.Y., addressed the Branch on "Recent Achievements in Colour Photography." Visiting ladies were the guests of the members of the Branch and after the lecture 187 members and ladies, together with a large delegation from the Hamilton Camera Club, enjoyed refreshments in the library of McMaster University.

Mr. Johnson spoke of the progress of photography from its early stages, showing many interesting slides.

The visible spectrum, he explained, is a narrow band compared to the range of invisible light; infra red having a longer wave length and ultra-violet a shorter wave length than that of visible light. With infra red it is possible to photograph scenes not visible to the naked eye at 200 miles distance. Ultra-violet will penetrate eleven inches of steel and will make old, faded documents legible.

Introducing his explanation of colour photography, the speaker showed a beautiful coloured slide of flowers, then the same photograph was shown in black and white and a sigh of disappointment came from the spectators. Colour photography is based on a blending of the three primary colours of white light, blue, red and green or their complementaries, yellow, magenta and blue-green. When white light shines on a red transparent medium, only red light passes through, and blue and green are absorbed. Similarly blue absorbs all but blue light, and green passes only green light. Based on these principles photographic films have been made with three, separated, sensitive layers each of which reacts to one of the colours. The developing of a coloured film requires twenty-seven processes and takes three hours.

There are two systems of colour photography, the Additive and Subtractive systems, and their relation can be illustrated by picturing a triangle whose sides are the colours yellow, blue-green and magenta; whose apices are the combination of the adjacent sides and whose centre is the combination of all three colours. When yellow and blue-green overlap, that is, when they shine independently on the same area or are added, the resultant is green. Similarly, blue-green and magenta produce blue, and magenta and yellow give red. The centre of the triangle where all colours overlap is black and such overlapping of colours is known as the Additive system. In taking a colour photo by this system it is necessary to make three shots, each with a different filter. The colour reproduction is good, but dense, and requires so much light for projection that special cooling arrangements must be provided. In the Subtractive system the process is reversed. Instead of the primary colours, the complementary colours are used. For example, when white light shines on blue-green, each of the primary colours in the combination, namely, blue and green, are passed and red, the colour wanted, is absorbed. Following the address Mr. Johnson showed a reel of coloured motion pictures depicting "The Growth of Transportation on the American Continent Through 150 Years," as depicted in the pageant performed at the recent exposition at Cleveland.

The speaker was introduced by W. J. W. Reid, A.M.E.I.C., vice-chairman of the Branch, and G. Moes, A.M.E.I.C., proposed a vote thanks. Colonel E. G. MacKay, A.M.E.I.C., presided at the meeting.

## Kingston Branch

*R. A. Low, A.M.E.I.C., Secretary-Treasurer.*

The annual meeting of the Kingston Branch was held on October 25th, 1937, and the following were elected officers: Chairman, Major H. H. Lawson, M.E.I.C.; Vice-Chairman, Prof. W. L. Malcolm, M.E.I.C.; Sec.-Treas., R. A. Low, A.M.E.I.C.; Executive, J. B. Wilkinson, A.M.E.I.C., R. F. Legget, A.M.E.I.C.; (ex-officio), Lt.-Col. L. F. Grant, M.E.I.C., Lt.-Col. N. C. Sherman, M.E.I.C., J. E. Goodman, A.M.E.I.C.

A report of the Branch activities during the season 1936-37 was presented. The Branch had met on five occasions and a statement of membership at the present time showed an increase of 13 over the previous year. A bank balance of $50.65 was carried forward in comparison with a balance of $63.54 of the previous year.

Regret was expressed at the determination of Lt.-Col. L. F. Grant to resign as Branch Secretary, a position which he has so ably filled for the past nine years.

### The Boulder Dam

At the first public meeting of the Branch this season, an interesting lecture on "Boulder Dam" was given by S. C. Hollister, Dean of the School of Engineering, Cornell University, in Convocation Hall, Queens University, on Friday, November 12th.

The lecture was largely attended by both the staff and students of Queens University and the Royal Military College.

Prior to the lecture, a complimentary dinner was given for Dean Hollister at the Badminton Club, other guests including Principal Wallace and Dr. McNeil of Queens University, Brigadier Matthews, Prof. Richardson of the Royal Military College and several members of the Peterborough Branch.

The speaker, who was consulting engineer for Babcock and Wilcox on the Boulder Dam project, has been responsible for much of the development in concrete design and practice on this continent in recent years.

Introduced by Prof. W. L. Malcolm, under the chairmanship of Major H. H. Lawson, Dean Hollister commented on the magnitude of the project, and the impossibility of covering the subject with the short time at his disposal. He justified the project for three reasons other than power development, stating that its primary purpose was to provide adequate flood control for the Colorado river, provide irrigation for the Imperial Valley in Southern California, as well as provide a domestic water supply for Los Angeles and irrigation for the citrus fruit growing region near that city.

Illustrating his lecture with both slides and moving pictures, he outlined the development of the project from its inception, laying particular stress on the design of the dam and the penstocks. While keeping general features in the foreground, he described many interesting problems in research and design which were encountered in this vast undertaking.

The lecture was followed by a series of motion pictures showing general construction features during the progress of the work, and the interest evoked was clearly indicated by the numerous questions.

A hearty vote of thanks, moved by Dean A. L. Clark, Hon.M.E.I.C., of Queen's University, was tendered the speaker for his excellent lecture.

## Lethbridge Branch

*E. A. Lawrence, S.E.I.C., Secretary-Treasurer.*
*R. F. P. Bowman, A.M.E.I.C., Branch News Editor.*

The regular dinner meeting was held on Saturday evening, October 9th, with 24 members and guests present. Music was supplied by Mr. Geo. Brown and his quartette, and community singing was enjoyed. A much appreciated solo was also rendered by Mr. Stott.

A feature of the dinner hour was the presentation to the club of a gavel, by Messrs. Cross, DeHart and Bowman, the gavel having been made by these gentlemen from a part of the first wrecking car on the Alberta Railway and Irrigation Company's line.

The minutes of the last meeting were then read and approved, and the report of the Chairman of the Programme Committee received. The speaker of the evening, J. T. Watson, A.M.E.I.C., City Manager, was then introduced by Mr. Wm. Meldrum.

Mr. Watson said that the original power plant in the City was owned by the Lethbridge Water and Electric Co. and was located at the west end of 1st Ave. S. This was rather small and the service poor, but with the building of a new plant in 1906 service was improved. This plant was taken over by the municipal authorities in 1908, but was burned down on New Year's Eve, 1909, and a new plant at the present site rushed to completion in 1910. Mr. Watson came here himself in 1916, and it is interesting to note that there are now only two pieces of the equipment of the 1916 plant remaining.

The speaker quoted a number of figures to show the past and present state of the finances of the plant, and the present high efficiency. In 1915 the plant used 5.37 lb of coal to produce one kilowatt hour, in 1936 it used 2.55 lb. of coal to produce a kilowatt hour.

He then showed a number of slides of the boilers, generators, etc., in use before the present equipment was installed, the present boilers, and their accessory equipment, the present generator and standby units, switchboards, and sub-stations, and the pumping and filtration plants.

At the conclusion of the address, Mr. Arthur Reid, also a former city power plant superintendent, moved a hearty vote of thanks to the speaker, and the meeting closed with "God Save the King."

### November Dinner Meeting

A dinner meeting and Ladies Night was held at the Marquis hotel, November 6th, 1937, with 60 members and ladies present. During the dinner, music was supplied by George Brown's instrumental quartette, following which vocal solos by Miss Jean Gibson and Mr. Terrence Horne, piano duets by Jack DeHart and Ross Robinson, and monologues by Mr. Alex Branch were enjoyed. Community singing was led by Mr. Bob Lawrence.

The speaker of the evening was Mr. Jack DeHart, son of J. B. DeHart, M.E.I.C., whow as one of the Canadian student representatives at the coronation of His Majesty King George VI, and gave an interesting account of his trip. There were 168 boys and 150 girls in the Canadian contingent. The boys sailed from Montreal at the end of April and landed at Southampton, going to London, where quarters were provided.

On coronation day the students were in place at their stands opposite Buckingham Palace Gate at 7.30 a.m. and from there watched the grand and impressive procession from the Palace to Westminster Abbey.

During the next few days numerous gatherings were held for the students. Stanley Baldwin addressed them at the Royal Albert Hall, and the Archbishop of Canterbury preached at a special service in Westminster Abbey.

Following the address, the chairman, J. M. Campbell, A.M.E.I.C., DeHart, M.E.I.C., who was one of the Canadian student representatives paid a glowing tribute to J. D. DeHart, who is leaving Lethbridge to reside in Calgary. Mr. DeHart's enthusiastic and conscientious work in connection with the Branch has largely contributed to the success of its activities. Mr. Campbell then presented Mr. and Mrs. DeHart with travelling bags as a token of appreciation and friendship from the Branch. Both Mr. and Mrs. DeHart spoke briefly in acknowledgement.

## London Branch

*D. S. Scrymgeour, A.M.E.I.C., Secretary-Treasurer.*
*Jno. R. Rostron, A.M.E.I.C., Branch News Editor.*

The October meeting of the Branch was held on the 20th at Wong's Cafe and took the form of a dinner meeting to welcome Mr. Durley.

After a substantial repast which all enjoyed, A. O. Wolff, M.E.I.C., chairman of the Branch, presided, and after the reading of the minutes called attention to the fact that Headquarters had agreed to the request of the London Branch Executive that the next Annual General Meeting of The Institute be held in London. After consultation with Headquarters, the dates upon which the meeting would be held have been fixed for January 31st, 1937, and February, 1st and 2nd, 1938 (Monday, Tuesday and Wednesday), at the Hotel London.

The evening was devoted to making preliminary arrangements for the next Annual Meeting and much helpful advice was given by Mr. Durley, drawn from his long experience in such matters.

At the conclusion, a hearty vote of thanks was expressed by J. A. Vance, A.M.E.I.C., seconded by H. F. Bennett, M.E.I.C., and unanimously carried.

About 20 members were present.

## Montreal Branch

*E. R. Smallhorn, A.M.E.I.C., Secretary-Treasurer.*

### The Isle of Orleans Suspension Bridge

On October 21st, 1937, D. B. Armstrong, A.M.E.I.C., of the Dominion Bridge Company, presented a paper on "Pre-stressing and Erection of Isle of Orleans Suspension Bridge." The speaker was supervising engineer of the construction of this bridge and was therefore well qualified to describe the problems which were met and overcome in fabricating and erecting this bridge. He also discussed the methods used in pre-stressing the suspension cables and erecting them at the site.

P. L. Pratley, M.E.I.C., was in the chair.

Technical Men in Industry

"Technical Men in Industry" was the subject under discussion at the meeting on October 8th, when Messrs. C. A. Peachey, Northern Electric Co., and Dr. H. G. Littler, Canadian Industries Limited, were the speakers. The first paper outlined the functions of the technical man, his present resposibilities, and future possibilities. The engineer's place under modern conditions and his responsibility in the reduction of costs were the principal points stressed.

Dr. Littler believed that unless a drastic change took place in the viewpoint of the technical man his voice was not likely to be heard in the planning of new industrial organizations in the future, as the engineer was lacking in proper training and experience in economics.

The chairman was Dean Ernest Brown, M.E.I.C.

Canadian Air Transportation

Mr. G. A. Thompson, General Manager of the Canadian Airways, Ltd., Winnipeg, on November 4th gave a most interesting address covering the history of commercial flying in Canada and other countries, the development of types of planes for Canadian use, and the present requirements of a general purpose aircraft for northern transportation. The economics of the operation of the commercial planes were also discussed.

Prior to the meeting an informal dinner was held at the Windsor hotel.

Chairman: G. G. Ommanney, M.E.I.C.

Junior Section

On November 8th an interesting visit was made to the hydraulics laboratories of the Ecole Polytechnique.

These laboratories, the most modern in Canada, were designed and built under the supervision of Professor Armand Circé. They are primarily equipped for teaching purposes but are also suitable for research work and studies on models of spillways with various profiles are at present being made.

The laboratories are equipped with a hydraulic turbine, small models of turbines and a 120 ft. channel with a spillway 4 ft. wide.

Mr. Raymond Boucher, M.Sc., C.E., Jr.E.I.C., Professor of Hydraulics at the Ecole Polytechnique and a graduate of Massachusetts Institute of Technology, gave a short description of the laboratory and particulars of the research work recently undertaken.

Electrical Operating Problems

Four short papers dealing with operating problems in the electrical industry were presented before the Branch on November 11th. It is understood that these are the first of the series which will discuss operating problems of the main Canadian industries. The subjects and authors were as follows:

"Operating Difficulties in Maintaining Service," by R. N. Coke, A.M.E.I.C.; "66 k.v. Cable Operation in Montreal," by A. Benjamin, A.M.E.I.C.; "Load Trends on the Island of Montreal and Vicinity," by G. C. Read, these three speakers all being from the Montreal Light, Heat and Power Consolidated; "Ground Resistance Measurements for Large Substations," by J. M. Crawford, A.M.E.I.C., Shawinigan Water and Power Company.

Chairman: G. R. Hale, A.M.E.I.C.

Junior Section

Montreal Locomotive Works, Montreal, received an inspection by the members of the Junior Section on Saturday afternoon, November 13th. Work in progress in the shops of the company included several locomotives of the Canadian Pacific Railway, 2800 class. These and other features proved of great interest.

## Niagara Peninsula Branch

*G. E. Griffiths, A.M.E.I.C., Secretary-Treasurer.*
*J. G. Welsh, S.E.I.C., Branch News Editor.*

On October 28th the Niagara Peninsula Branch was the guest of the Engineering Society of Buffalo for an instructive and enlightening afternoon and evening.

Members of the two organizations met at 1.30 o'clock in the afternoon in the Statler hotel, Buffalo, and divided into two groups one of which was taken on a conducted tour of the new "Strip Mill" of the Bethlehem Steel Company at Lackawanna. It was an excellent time to see this plant since at this season the production rate for the light gauge steel which they roll is quite high. This product now being used in large quantities for the making of car bodies and fenders.

The second group made an inspection trip of the treatment plant of the new Buffalo Sewage System. The original plans had been that the trip would be an inspection of the main works of the whole system but owing to wet underground conditions this part of the trip was impossible.

At 7 o'clock the groups reunited in the Statler Hotel to join in an enjoyable dinner. Mr. J. G. Ullmann, chairman of the Engineering Society of Buffalo, made a short speech of welcome to members of the Niagara Branch which was followed by a toast to the King. L. C. McMurtry, A.M.E.I.C., chairman of the Niagara Peninsula Branch, extended the good wishes and thanks of the Canadian group and hoped that the two organizations would again be able to get together in the form of a meeting on this side of the border.

Following the dinner, the meeting adjourned to the assembly hall of the hotel for moving pictures with sound descriptions of the construction of the new Golden Gate bridge. The first picture presented by John A. Roebling's Sons Company proved to be most interesting in that it depicted practically every phase of the erection of the suspension cables. One of the most instructive parts of the picture was the showing of the principles of spinning cables for a suspension bridge and how the rate of spinning cables has increased in the latest bridges of this type. This has been done by both increasing the number of cable carrying wheels and by increasing their speed of travel.

The second picture showed the construction of the towers and stiffening trusses of the suspended span of the same bridge and was presented by the Bethlehem Steel Company.

## Ottawa Branch

*R. K. Odell, A.M.E.I.C., Secretary-Treasurer.*

Some Recent Developments in Aircraft Fuels

At the first noon lucheon of the new fall and winter season held at the Chateau Laurier on October 14th, M. S. Kuhring, Mechanical Engineering Division, National Research Laboratories, gave an address on "Some Recent Developments in Aircraft Fuels." His address dealt largely with three general problems at present facing the refiners and the manufacturers and users of aircraft engines. These relate to vapour pressure, distillation range and octane number, three considerations closely interconnected and of relatively equal importance.

Vapour pressure the speaker defined as the property which controls vapour lock or interference of the metering of the fuel by the carburettor due to evaporation before passing through the carburettor jet. The vapour lock may result in either excessively lean or excessively rich mixtures which of course may not be tolerated. In most of the specifications today for aircraft engine fuels the maximum permissible vapour pressure is seven pounds per square inch.

Aeroplanes today are capable of climbing so rapidly that quite often the fuel in the tanks is actually boiling when the ceiling is reached, due to a lag in the drop of the fuel temperature combined with the reduced atmospheric pressure to which the fuel is subjected. Very volatile fractions in fuels of the future, therefore, may have to be somewhat restricted, though on the other hand such fractions have good anti-knock value and starting properties.

The distillation range is related to the starting possibilities of the fuel when used in an engine, to its tendency toward vapour lock and to its power of distribution and acceleration. Certain refiners believe that volatility plays a part in motor fuels as great as lead in regard to anti-knock quality.

This, stated Mr. Kuhring, may be true to a large extent for those used in automobile engines—butane has been added to some fuels so used with success—but for aircraft engines there is always the vapour pressure to be taken into account. This whole question, according to the speaker, is one of great complexity and well worthy of a paper by itself.

The greater portion of the address was devoted to the octane number or anti-knock quality of the fuel which the speaker characterized as "by far the most interesting single property of aircraft fuels today."

Shortly after the Great War the phenomenon of detonation was first observed in connection with engines. Damaged pistons, cylinders and valves due to this cause had, of course, previously been encountered. Quite properly, they were ascribed to overheating and remedial efforts were usually directed toward trying out new types of cowling. But there was more than this to the question.

With the efficiency of an internal combustion engine depending upon the density of the charge in the combustion chamber before ignition the natural thing was to attempt to increase the specific power output by increasing the compression pressure. But such attempts soon resulted in sudden and unnatural temperature increases generally accompanied by knocking or pinking sounds. This discovery has led to a vast amount of investigational work, which is still being carried on.

For carrying on such investigations the single-cylinder CFR engine has been developed to test the resistance of fuels to detonation, and two chemically pure hydrocarbons have been selected which may be mixed in any definite proportion to match the anti-knock value of whatever fuel may be under test. After much experimentation, iso-octane and normal heptane have been selected for this purpose as basic reference standards, the former having a much higher resistance to detonation than the latter. In comparative tests as carried out with the CFR engine under certain rigidly controlled operating conditions the percentage of iso-octane in the blend of iso-octane and normal heptane which just matches the unknown fuel in anti-knock value is known as the "octane number." In other words, if 87 per cent of iso-octane is required in the blend of iso-octane and normal heptane to match the anti-knock value of an aviation fuel, then that fuel will have an octane number of 87.

Mr. Kuhring then described some of the rigidly controlled conditions under which the engine must be operated in carrying on the tests. Some years ago, he stated, the aircraft fuels in use ranged from

66 to 73 octane number. They then moved up to 80 and then to the 87 which is in use at the present time. Fuels of much greater octane number, even to those greater than 100, are now being considered; and while it may be a little time before they are in general use they will no doubt be produced commercially to meet the demand. The usual practice in rating the very high test fuels is to report them as being "iso-octane plus so many c.c.'s of lead," since the octane scale does not go above 100.

To give an idea of what the increase in octane number may mean to the engine manufacturer and the operator, Mr. Kuhring instanced the case of an engine which started out with a horsepower under 600 but which, thanks to the fuel now available, is capable of over 1,200 h.p. without any increase in speed of the engine.

#### Canadian Hydrographic Service on the Pacific Coast

Henri Delpe Parizeau, District Hydrographer of the Canadian Pacific Coast, gave a talk at the luncheon, October 28th, on the "Canadian Hydrographic Service on the Pacific Coast." J. G. Macphail, chairman of the Ottawa Branch, presided and other head table guests included: G. J. Desbarats, president of The Institute; J. B. Challies of Montreal, F. H. Peters, S. J. Chapleau, G. B. Dodge, and R. J. Fraser.

Mr. Parizeau first of all traced the history of the Canadian Pacific coast with particular reference to exploration, coast line and hydrographic surveys from the early days to the present. Captain Cook, who brought the first British ship into these waters in 1778, he stated, "had done more for North America than any general, admiral, scientist or hydrographer." He was the father of the hydrographic service of the British Isles and the grandfather of the hydrographic service of Canada; and it was distinctly unfortunate that his memory was not commemorated by a monument in Canada.

With a coast line five times as long as the distance from Halifax to Vancouver, with 1,150 miles of open water and 4,500 miles of inland channels, some of them extending back as much as 75 miles from the open sea, with high hills and mountains lining the coast, the tops of which were frequently in the clouds, and with periods of extended rainfall, there are plenty of natural difficulties to be encountered on the hydrographic survey.

The speaker described some of the methods and equipment used and gave details regarding the survey ship the *W. J. Stewart*, which was named after the late chief hydrographer.

As an instance of the manner in which methods have progressed, whereas formerly many hours were required to take individual sounding in deep water now the same thing can be done by modern methods in a few seconds.

## Peterborough Branch

*W. T. Fanjoy, A.M.E.I.C., Branch Secretary.*
*J. L. McKeever, Jr.E.I.C., Branch News Editor.*

The first technical meeting of the season was held on October 28th, 1937, at which the speaker was John Grieve, A.M.E.I.C., Promotion Manager, Imperial Varnish and Colour Co., Toronto, on the subject of "The Manufacture of Paints and Varnish with relation to Weathering, Durability, and Insulating Properties."

Mr. Grieve started his talk by describing the basic materials used in paint manufacture, the oils, pigments, pigment bases etc., and was able to show samples of most of the materials he mentioned. He made mention of the sources of the various materials and the amount of work that is being done to find substitutes for imported material, as for example china-wood oil, the trade in which has practically been stopped by the present Sino-Japanese War.

The speaker next went on to describe the various types of paints and their uses, pointing out cases where the older standard preparations were now being replaced by better modern substitutes, a case in point being the supplanting of red lead by lead chromate as a primer for steelwork.

He gave some interesting demonstrations of the precipitation of various pigments and of the different properties of various commonly used oils. He stressed the necessity of the paint manufacturer being informed of the various conditions to be met with in any large job so that the correct paint might be applied and deprecated the common assumption that one paint would cover a multitude of different requirements.

Mr. Grieve proved to be a pleasant speaker, well versed on his subject and his talk was greatly enjoyed by the Branch. Attendance, 47.

#### Junior and Student Section

An interesting development in the activities of the Branch was the first meeting of the Discussion Club recently formed by the Junior and Student Section, held on October 21st, Mr. A. L. Malby was Chairman of the meeting, and the two speakers were: Mr. D. A. Drynan on "Lightning and Lightning Protection" and Mr. W. F. McMullen on "Single Phase Revolving Fields."

From the amount of discussion which took place it was evident that the first meeting of this kind was a distinct success and it is hoped that future meetings will evoke an equal amount of enthusiasm. Attendance, 25.

## Saint John Branch

*L. G. Lilley, Jr.E.I.C., Secretary-Treasurer.*
*H. P. Lingley, Jr.E.I.C., Branch News Editor.*

The regular monthly meetings of the Saint John Branch started on October 22nd, 1937, when about 30 members gathered in the Admiral Beatty hotel to hear Mr. W. R. McCaffrey, Secretary of the Canadian Engineering Standards Association, speak on the work of the association.

Mr. McCaffrey discussed briefly the set-up of the C.E.S.A. and explained how a specification was voted on before it became a standard.

He was followed by Mr. W. P. Dobson, Chief Testing Engineer of the Ontario Hydro-Electric Power Commission, who spoke at some length on "Laboratory Approval and Research Work."

Mr. Dobson gave a very interesting account of the Laboratory Branch of the Hydro Commission and went on to explain that there were three functions of the laboratory, namely, testing, research and approvals.

Mr. Dobson, who is Chairman of the Eastern Division of the Canadian Electrical Code Commission, and Mr. McCaffrey had just returned from a meeting in Amherst, N.S., of the Eastern Committee of the Code Commission, and this Branch was very fortunate in having them address us.

The chair was occupied by the chairman of the Branch, Mr. Sidney Hogg, who tendered a very hearty vote of thanks to the speakers, on the completion of their addresses.

#### Mineral Resources and World Politics

On Thursday, November 18th, 1937, the Saint John Branch held a regular meeting in the Admiral Beatty hotel with thirty members present. Sidney Hogg, A.M.E.I.C., presided, and the speaker was Professor H. W. McKiel, Dean of the Faculty of Engineering at Mount Allison University.

Professor McKiel's subject, "Mineral Resources and World Politics," gave the Branch a very interesting picture of the effect and importance of a country's mineral deposits, both in peace and war.

He discussed the use of metals from early times, and pointed out that all large industries were situated in certain areas depending on their mineral deposits. Conditions now, however, are different than before, as the present deposits are practically all used up, necessitating a move towards discovery of new deposits or importation from other countries.

Professor McKiel than gave a list of the countries in the order of their mineral importance, the countries of North and South America leading, with the United States at the head, owning or producing about 40 per cent of the world's supply. Canada has what amounts to a virtual monopoly in nickel, but is lacking in iron, importing an amount nearly equal to its other mineral productions.

On the whole, the mineral deposits of the various countries of Europe are on the decline, although little is known about Russia's future due to its large little known areas. Germany was deprived of nearly all her supplies of iron after the war, although there is no other so large an industrial country having such a poor supply of minerals. Much of Germany's unrest today is due to her loss of mineral resources.

In time of war, possession of important minerals is of supreme importance, as minerals mean munitions. A union of the United States and Great Britain would mean a practically undefeatable combination as the two countries together control more than 75 per cent of the world's supply.

After his address, Professor McKiel discussed the proposals for a scheme of union similar to Nova Scotia, and the meeting went on record as approving in principle the scheme as put forth by Professor McKiel.

## St. Maurice Valley Branch

*C. H. Champion, A.M.E.I.C., Secretary-Treasurer.*

#### Farewell Dinner to Bruno Grandmont, A.M.E.I.C.

A farewell dinner in honour of M. Bruno Grandmont was held on October 8th at the Chateau de Blois in Three Rivers. Members of the St. Maurice Valley Branch and of the Association of Professional Engineers gathered to say farewell to a fellow engineer who had been active in affairs for that region for many years past.

M. Grandmont, a past chairman of the Branch and a councillor of The Institute, has occupied the position of district engineer, Public Works of Canada, at Three Rivers for the past 16 years and is now being moved to Quebec.

John Wickenden, A.M.E.I.C., chairman of the Branch, presided at the dinner and mentioned, as did several other speakers, how much the Branch regretted losing M. Grandmont. M. Grandmont, in reply, thanked those present for offering their best wishes and for the honour done him. Messrs. Bonaventure and St. Cyr assisted in the organization of the dinner.

#### Grand'Mère Meeting

The Saint Maurice Valley Branch held their last meeting of the fall season in Grand'Mère, on Friday, November 5th, 1937, with some fifty members and visitors present. This meeting took the form of a dinner meeting prior to which cocktails were served in the Men's Club. The party then adjourned to the Laurentide Inn for an excellent dinner.

The chairman of the Branch, Mr. John Wickenden, A.M.E.I.C., was in the chair. The guests present were Messrs. D. O. Robinson, A.M.E.I.C., and R. A. Crysler, A.M.E.I.C., of Toronto; E. A. Smallhorn, A.M.E.I.C., Secretary of the Montreal Branch, and J. F. Plow, A.M.E.I.C., Assistant Secretary of The Institute, Montreal.

At the conclusion of the dinner there was a short business meeting at which the Branch Nominating Committee for the naming of officers for the next year was elected. These were Messrs. H. O. Keay, M.E.I.C., W. B. Scott, A.M.E.I.C., and C. H. Champion, A.M.E.I.C.

Mr. Champion then gave a short résumé of the recommendations which resulted from the Round Table Conference of the Branch representatives which took place in Montreal at the time of the Semi-centennial Meeting of The Institute. Mr. Plow gave a short talk on The Institute and its work, stressing particularly what it was able to do for members of the Saint Maurice Valley Branch.

Professor Keay then introduced the speakers, Messrs. D. O. Robinson and Mr. R. A. Crysler of the Canada Cement Company of Toronto.

Mr. Robinson, who undertook to give a general talk on Portland cement and concrete, referred particularly to recent developments in highway and bridge construction. Mr. Crysler, who followed, carried the subject on to include many types of reinforced concrete structures in United States, Canada and Europe. Some very excellent slides were shown and the general consensus of opinion was that they did not believe that a discussion on concrete could have been made so interesting.

The speakers were thanked by E. B. Wardle, M.E.I.C., heartily supported by those present.

## Toronto Branch

*J. J. Spence, A.M.E.I.C., Secretary-Treasurer.*
*A. E. Berry, M.E.I.C., Branch News Editor.*

The opening meeting of the Toronto Branch was held on October 21st, 1937. A. U. Sanderson, A.M.E.I.C., chairman of the Branch, occupied the chair. The speaker was Professor C. R. Young, M.E.I.C., of the University of Toronto, and his subject "Modern University Training for Civil Engineers."

The speaker described the development of engineering education in this and in other countries. Perronnet, who instituted in 1747, in France, a scheme of instruction for designers of bridges and highways may be considered to be the father of engineering education. Early civil engineers in Britain received their training through articled pupilage to practising engineers, and engineering schools as we now know them were slow in arriving.

On this continent, the first engineering college to have a continuous existence, and the first of its kind to be established in any English speaking country, was the Rensselaer Polytechnic Institute at Troy, N.Y., founded in 1824.

Modern engineering education in Ontario began in 1878 with the founding of the Ontario School of Practical Science, now the Faculty of Applied Science and Engineering of the University of Toronto. In each of the three Departments of Civil, Mechanical and Mining Engineering, then announced, the avowed object was to afford a thorough education in physical science with a direct bearing on the occupation which students might wish to follow.

Professor Young stated that the choice of subjects at that time was excellent, and that whatever changes have been made in the past 60 years have for the most part pertained to the extension of the field and intensity of each subject, or the subdividing of it to conform to the astounding growth of scientific knowledge. Realizing that the work of the engineer is that of a co-ordinator of many sciences to the end that he may achieve a desired result, the university has added to the curricula numbers of subjects of a business, economic, or cultural character, such as Business, Technical English, Economics and Finance, Commercial Law, Engineering Law, Management, Engineering Economics, Contracts and Specifications, Municipal Administration, and Public Speaking.

An interesting phase of the address was the statement that during recent years the trend has been away from marked specialization within the long-established engineering departments. Thus, in Civil Engineering, election of subjects is limited to about 15 per cent of the time in the fourth or final year. A broad, fundamental training has been found best having regard to the employability of graduates.

Students entering the university have ample opportunity of specialization in the choice of the department in which they register.

For the average student of engineering, four years is the maximum practicable length of time to spend in college, but others find it advantageous to return for graduate work, and to take up subjects of an advanced character. Only three schools on the continent have engineering courses longer than four years; one of three years arts and three years engineering; and two others of five straight years of engineering.

The meeting was well attended, and the discussion which followed was broad and of considerable interest.

## Winnipeg Branch

*A. E. Macdonald, M.E.I.C., Chairman.*
*H. L. Briggs, A.M.E.I.C., Branch News Editor.*

### Acoustics

On October 21st, 1937, Dr. W. J. Hodge, Chief Acoustical Engineer, Johns-Manville Company, New York City, gave the members of the branch an instructive and interesting evening on the above subject. Commencing with a sound film which set forth the principles of sound production and propagation, reflection, refraction, and the manner in which the human ear is influenced, he proceeded to demonstrate sound level, absorption, reverberation, echoes, and the focusing of sound by curved surfaces to produce local areas in auditoria where the acoustics were particularly poor. Means were shown whereby rooms were soundproofed by producing "discontinuities" across which vibration did not carry. In special cases floors, walls and ceilings were carried on sound isolators consisting of saddles supported on hair felt pads.

J. W. Porter M.E.I.C., expressed the appreciation of the large audience to the speaker.

The chairman noted with much regret the departure of F. G. Goodspeed M.E.I.C., from Winnipeg, and assured him of the good wishes of the Branch on the occasion of his appointment to the Board of Engineers, Department of Public Works, Ottawa.

### The Cyanide Process

In an interesting paper on November 4th, G. E. Cole, A.M.E.I.C., Director of Mines, Department of Natural Resources, Province of Manitoba, described the history and improvement of the cyanide process for the extraction particularly of gold from its ore. The years 1886 to 1900 marked the birth and success of the cyanide method, 1900 to 1912 the consolidation of the process and progress in grinding the ore, while from 1912 until the present has witnessed the intense development of special machinery.

The steps in the process as used at present are:

(1) Preparation of the ore for cyaniding.
(2) Dissolving of the gold from the finely ground rock to form a pregnant solution.
(3) Separation of the finely ground rock from the pregnant solution.
(4) Precipitation of the gold.
(5) Separation of the gold from the barren solution.
(6) Conversion of the gold sludge to gold.

After a number of slides and considerable discussion, Professor N. M. Hall, M.E.I.C., expressed the thanks of those present to the speaker.

## List of New and Revised British Standards

(Issued during July, August and September)

*B.S. No.*

37—1937. *Electricity Meters.* (*Revision*).
Extended to include "long-range" meters, and meters of sizes up to 6,000 amperes. The permissible limits of error have been reduced wherever possible.

153—Pts 3, 4, and 5—1937.
*Girder Bridges.* (*Revision*): *Part 3, Loads and Stresses*; *Part 4, Details of Construction*; *Part 5, Erection.*
Revision of portions of the B.S. Specification for Girder Bridges issued in 1923, and additions made to Parts 3, and 4.

209—1937. *Fuel Oils for Diesel Engines* (*Petroleum and Shale Oils*) *including Methods of test.* (*Revision*).
Issued as a result of the development of the modern high speed diesel engine. It deals with oils of petroleum and/or shale origin and includes a grade of oil suitable for engines for automotive and allied purposes of speeds in excess of 800 r.p.m., together with other grades for medium and slow running engines.

240—1937. *Method and Tables for Brinell Hardness Testing.* (*Revision*).
Revision of 1926 issue incorporates amendments relating to the manner of carrying out the test, principally in regard to the thickness of the test specimen, the appropriate $\frac{P}{D^2}$ ratio, and the time of application of the load.

742—1937. *Fuel Oils for Burners* (*Petroleum and Shale Oils*) *including Methods of Test.*
Deals with hydro-carbon oils of petroleum and/or shale origin. There are two schedules for fuels for domestic purposes, two for marine purposes and four for industrial purposes.

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*Canadian Car and Foundry Company Limited* have issued an interesting and useful catalogue of mining equipment. The book has been prepared in loose-leaf form and the present contents includes various types of mine cars, narrow gauge track work for light industrial railways, car wheels, wheel and axle mountings, crusher and grinding parts, mill liners, etc.

In addition to a large number of photographic illustrations, dimensional drawings and detail specifications are included.

# Preliminary Notice

### of Applications for Admission and for Transfer

November 24th, 1937

The By-laws provide that the Council of The Institute shall approve, classify and elect candidates to membership and transfer from one grade of membership to a higher.

It is also provided that there shall be issued to all corporate members a list of the new applicants for admission and for transfer, containing a concise statement of the record of each applicant and the names of his references.

In order that the Council may determine justly the eligibility of each candidate, every member is asked to read carefully the list submitted herewith and to report promptly to the Secretary any facts which may affect the classification and selection of any of the candidates. In cases where the professional career of an applicant is known to any member, such member is specially invited to make a definite recommendation as to the proper classification of the candidate.*

If to your knowledge facts exist which are derogatory to the personal reputation of any applicant, they should be promptly communicated.

**Communications relating to applicants are considered by the Council as strictly confidential.**

The Council will consider the applications herein described in January, 1938

R. J. Durley, Secretary.

*The professional requirements are as follows:—

**A Member** shall be at least thirty-five years of age, and shall have been engaged in some branch of engineering for at least twelve years, which period may include apprenticeship or pupilage in a qualified engineer's office, or a term of instruction in a school of engineering recognized by the Council. The term of twelve years may, at the discretion of the Council, be reduced to ten years in the case of a candidate for election who has graduated from a school of engineering recognized by the Council. In every case the candidate shall have held a position in which he had responsible charge for at least five years as an engineer qualified to design, direct or report on engineering projects. The occupancy of a chair as a professor in a faculty of applied science of engineering, after the candidate has attained the age of thirty years, shall be considered as responsible charge.

**An Associate Member** shall be at least twenty-seven years of age, and shall have been engaged in some branch of engineering for at least six years, which period may include apprenticeship or pupilage in a qualified engineer's office or a term of instruction in a school of engineering recognized by the Council. In every case a candidate for election shall have held a position of professional responsibility, in charge of work as principal or assistant, for at least two years. The occupancy of a chair as an assistant professor or associate professor in a faculty of applied science of engineering, after the candidate has attained the age of twenty-seven years, shall be considered as professional responsibility.

Every candidate who has not graduated from a school of engineering recognized by the Council shall be required to pass an examination before a board of examiners appointed by the Council. The candidate shall be examined on the theory and practice of engineering, with special reference to the branch of engineering in which he has been engaged, as set forth in Schedule C of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Sections 9 and 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard. Any or all of these examinations may be waived at the discretion of the Council if the candidate has held a position of professional responsibility for five or more years.

**A Junior** shall be at least twenty-one years of age, and shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year at the discretion of the Council if the candidate for election has graduated from a school of engineering recognized by the Council. He shall not remain in the class of Junior after he has attained the age of thirty-three years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

Every candidate who has not graduated from a school of engineering recognized by the Council, or has not passed the examinations of the third year in such a course, shall be required to pass an examination in engineering science as set forth in Schedule B of the Rules and Regulations relating to Examinations for Admission. He must also pass the examinations specified in Section 10, if not already passed, or else present evidence satisfactory to the examiners that he has attained an equivalent standard.

**A Student** shall be at least seventeen years of age, and shall present a certificate of having passed an examination equivalent to the final examination of a high school, or the matriculation of an arts or science course in a school of engineering recognized by the Council.

He shall either be pursuing a course of instruction in a school of engineering recognized by the Council, in which case he shall not remain in the class of Student for more than two years after graduation; or he shall be receiving a practical training in the profession, in which case he shall pass an examination in such of the subjects set forth in Schedule A of the Rules and Regulations relating to Examinations for Admission as were not included in the high school or matriculation examination which he has already passed; he shall not remain in the class of Student after he has attained the age of twenty-seven years, unless in the opinion of Council special circumstances warrant the extension of this age limit.

**An Affiliate** shall be one who is not an engineer by profession but whose pursuits, scientific attainments or practical experience qualify him to co-operate with engineers in the advancement of professional knowledge.

The fact that candidates give the names of certain members as reference does not necessarily mean that their applications are endorsed by such members.

## FOR ADMISSION

BINNS—FRANK, of Sackville, N.B., Born at Bradford, England, Dec. 9th, 1885; Educ., B.S., Tufts College, 1909. M.S. in Engrg., Purdue Univ., 1935; 1902-05, ap'tice, Lawrence Machine Co., Lawrence, Mass.; 1910-18, dftsman., Hamblet Machine Co., Lawrence; 1918-19, dftsman., Peter Cooper Hewitt, New York; 1919, detailer, Baldwin Locomotive Works, Philadelphia; 1925-27 (2 periods), 1928, designer of heavy machy., Cameron Machine Co., Brooklyn, N.Y.; 1927, designer of special machy., Wall Rope Works, Beverly, N.J.; 1929, designer of special machy., Brown-Bridge Mills, Troy, Ohio; 1919-24, instructor in mech. drawing, Univ. of Pennsylvania; 1924-25, instructor in mechanics, Pennsylvania State College; 1928, instructor in engrg. drawing, Texas Technological College; 1929-33, instructor in practical mechanics, Purdue Univ.; 1936 to date, instructor in engrg. drawing, Mount Allison University, Sackville, N.B.
References: H. W. McKiel, F. L. West, H. W. Read, J. F. F. Mackenzie, C. A. Fowler.

BURLTON—GEORGE ARNOLD, of 26 Union St., Halifax, N.S., Born at Halifax, April 28th, 1912; Educ., B.Eng. (Mech.), N.S. Tech. Coll., 1935; 1935-37, summers, paving inspr. on highways, and winters, asst. in engrg. dept., St. Mary's College, Halifax, N.S.
References: S. Ball, L. B. Feetham, J. J. Sears, A. F. Dyer.

CARLEY—FOREST CECIL, of Montreal, Que., Born at Consecon, Ont., June 17th, 1895; Educ., B.A.Sc., Univ. of Toronto, 1923; 1923-24, meter calculation and calibration, and 1924-27, sales and service engr., Bailey Meter Co.; 1928-33, with Chambers & Carley, Toronto. Air conditioning, automatic control for heating, calibrations in liquid measures; 1933 to date, manager, Montreal office, Affiliated Engineering Corps. Ltd., Montreal, Que.
References: W. L. Yack, N. E. D. Sheppard, O. Biedermann, W. W. Timmins, G. L. Wiggs.

CHAPLIN—HERBERT ELLIOTT, of Montreal, Que., Born at St. John's, Nfld., Sept. 2nd, 1910; Educ., B.Eng. (E.E.), McGill Univ., 1934; With the Imperial Tobacco Co. Ltd., Montreal, as follows: 1933, machine shop; 1933-34, dfting. office; 1934-36, factory engrg. dept., 1936 to date, asst. factory engr.
References: C. V. Christie, E. Brown, J. T. R. Steeves, N. C. Cameron, C. M. McKergow.

DYSON—VINCENT SEDDON, of 229 Maple Ave., Welland, Ont., Born at Sheffield, Yorks., England, March 30th, 1879; Educ., private study; 1900-04, mgr. and underground mgr., Stannington Wood Colliery; at present, supt., heavy forging plant, Canada Foundries & Forgings Ltd., Welland, Ont.
References: C. H. M. Burns, H. A. Ricker, W. R. Manock, M. B. Atkinson, P. E. Buss.

GODFREY—WILLIAM ROBERT, of Chatham, N.B., Born at Chatham, Apr. 10th, 1914; Educ., B.Sc., Univ. of N.B., 1935; 1934-35, survey foreman, Public Works of Canada; 1936, dftsman., Ross Realty Co.; at present, dftsman., cost keeper and engr.'s helper with Highway Divn., Dept. of Public Works of N.B., Chatham, N.B.
References: A. F. Baird, E. O. Turner, J. Stephens, G. H. Thurber, C. G. Grant.

HAINES—NEIL ST. CLAIR, of 1311 Pape Ave., Toronto, Ont., Born at Cheltenham, Ont., Jan. 22nd, 1910; Educ., B.A.Sc. (Civil), Univ. of Toronto, 1935; 1933-34 (summers), Algoma Summit Gold Mines Ltd.; 1935-36, instr'man., dftsman. and sub-foreman, Dept. of National Defence; 1936-37, quarry engr., Gypsum Lime and Alabastine Co. Ltd.; 1937 (Apr.-July), quarry engr., North American Cyanamid Co.; 1937 (July-Aug.), instr'man., Township of Scarborough; 1937 (Aug.-Nov.), instr'man., Dept. of Highways Ontario.
References: C. R. Young, W. J. Smither, G. R. Hill, W. E. Harry, C. F. Morrison.

HARTMANN—NICHOLAS LEOPOLD, of 1522 King St. East, Hamilton, Ont., Born at Poltawa, Russia, July 3rd, 1897; Educ., Dipl. Ing., Stuttgart Technical University, Germany; 1919-20, ap'tice, at machine works, Hartmann Ltd., Offenbach, and Union Garage, Paul Rompel, Frankfurt; 1922 (Aug.-Sept.), machinist, German Shipbldg. Co., Hamburg; Dec. 1922-Jan. 1933, asst. worker, Robert Bosch Ltd., Stuttgart; 1920 (Aug.-Oct.) and Dec. 1920-Jan. 1921, dftsman., Sanitaria Ltd., Ludwigsburg; 1924-25, designer, The Ernst Heinkel Airplane Corpn., Warnemuende; 1925-26, designer for special problems, German-Power Plow Co. Ltd., Berlin; 1927 (Jan.-Mar.), engr. and dftsman., The Drill Plow Co., Morden, Man.; 1927-28, inspr., International Harvester Co., Hamilton, Ont.; 1928-30, dftsman. in experimental dept. of same company; 1931 (Mar.-Oct.) and March 1934 to date, dftsman., Steel Company of Canada, Hamilton, Ontario.
References: R. E. Butt, A. B. Dove, W. Hollingworth, E. G. MacKay, A. R. Hannaford.

HUTTON—FRANCIS SPENCE, of 47 Undermount Ave., Hamilton, Ont., Born at Hamilton, Mar. 9th, 1914; Educ., B.A.Sc., Univ. of Toronto, 1936; Summers, 1934, H.E.P.C. of Ont., tourist guide at Queenston generating stn., 1935, instr'man and rodman, Geol. Survey of Canada; With the C.N.R. as follows: 1936 (May-Nov.), constrn. dept., Midland, Ont., 1936-37, rodman and instr'man., Senneterre-Rouyn Branch line, and Sept. 1937 to date, levelman.
References: R. A. Baldwin, W. B. Redman, C. R. Young, W. J. Smither, J. J. Traill.

LeCOINTE—PIERRE LEON PAUL, of Montreal, Que., Born at Paris, France, May 7th, 1882; Educ., Civil Engrg., Ecole Nationale des Ponts et Chaussees, Paris, 1904-08; 1907, field engr., 1908-09, office engr., Paris-Orleans Rly.; 1911-12, asst. designing engr., 1912-16, technical asst. to the supt., Montreal Water Works; 1916-17, office engr., road dept., City of Montreal; 1917-30, professor of industrial chemistry, Ecole Polytechnique, Montreal; 1931 to date, consltg. engr., (F. J. Leduc & Associates), Montreal, Que. (R.P.E. of Que.) (Member, Soc. Ing. Civils de France.)
References: A. Frigon, O. O. Lefebvre, A. Mailhiot, E. Cormier, J. E. Blanchard.

LEDUC—FRANCOIS J., of 10832 Henri Julien, Montreal, Que., Born at St. Benoit, Que., Nov. 21st, 1895; Educ., B.A.Sc. (Political Sciences), 1924, D.A.Sc. (H.C.), Ecole Polytechnique, Montreal; R.P.E. of Que.; 1916-19, chemist, metallurgist, Canadian Inspection and Testing Laboratory, Montreal; 1919-21, asst. supt., Belgo Canadian Pulp and Paper Co.; 1921-22, metallurgist, General Car and Machinery Ltd., Montmagny, Que.; 1924-31, director of lab. for testing materials, City of Montreal; 1931 to date, consulting engr., and at present, Minister of Highways, Province of Quebec
References: A. Frigon, T. J. Lafreniere, O. O. Lefebvre, A. Mailhiot, J. A. Lalonde.

MILLER—CHARLES ARTHUR, of 825 St. Joseph Blvd. East, Montreal, Que., Born at Toronto, Ont. Mar. 24th, 1915; Educ., B.A.Sc., Univ. of Toronto, 1936; Summer work: operations clerk, dfting., Link Belt Ltd., Toronto; dfting and estimating, Toronto Iron Works; One term, demonstrator in thermodynamics, Univ. of Toronto; May 1936 to date, dfting, design and checking, Canadian Industries Limited, Montreal, Que.
References: A. B. McEwen, L. deB. McCrady, E. A. Allcut, R. W. Angus, R. C. Wiren.

PERRAULT—LUCIEN, of 4047 Vendome Ave., Montreal, Que., Born at Montreal, Jan. 25th, 1901; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1927; 1924-29, constrn. work (houses), Montreal Dairy, Independent Silk Co. Ltd. (chem. engrg.); 1929 to date, chief engr. and manager, Industrial and Commercial Laboratories Ltd., Montreal, Que.; 1937, professor, laboratory for testing materials, Ecole Polytechnique, Montreal.
References: J. A. Beauchemin, A. Mailhiot, A. Frigon, O. O. Lefebvre, J. A Lalonde, J. P. Leclaire, I. E. Vallee.

PREVEY—WARREN HARRY PRESTON, of 571 Aylmer Street, Peterborough, Ont., Born at Edmonton, Alta., May 30th, 1911; Educ., B.Sc. (E.E.), Univ. of Alta., 1934; 1936 to date, student engr., Can. Gen. Elec. Co. Ltd., Peterborough, Ont.
References: V. S. Foster, A. L. Dickieson, R. E. Hinton, H. R. Sills, W. T. Fanjoy.

RYAN—HOLLIS FRANKLIN, of Edmonton, Alta., Born at Truro, N.S., July 14th, 1906; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1926; 1923-24-25 (summers), electrn's helper and electrn.; 1926-27, student engr., 1927-28, design engr., 1928-30, application engr., 1930-31, apparatus service engr., 1931-32, sales promotion engr., 1935-36, apparatus sales engr., Can. Gen. Elec. Co., Toronto, and 1936 to date, manager, apparatus divn. for same company at Edmonton, Alta.
References: W. E. Cornish, W. I. McFarland, W. M. Cruthers, C. E. Garnett.

TRUDEL—ALPHONSE, of Three Rivers, Que., Born at St. Narcisse, Que., Feb. 11th, 1912; Educ., B.Eng. (M.E.), McGill Univ., 1937; 1926-36, general work in engrg. and control paper mills, etc., during vacations; at present, engrg. dept., Canadian International Paper Co. Ltd., Three Rivers, Que.
References: C. H. Champion, P. B. Hughes, K. S. LeBaron, C. M. McKergow, N. J. A. Vermette.

WYATT—DIGBY, of Toronto, Ont., Born at Toronto, Feb. 20th, 1904; Educ., B.A.Sc., Univ. of Toronto, 1925; 1923-24 (summers), roadways section, Dept. of Public Works, City of Toronto; 1920-21, assisted in experimental work re reinforcing concrete beams, Norman McLeod Ltd., General Contractors; 1935-37, industrial salesman, G. H. Wood & Co. Ltd., mfg. chemists; at present, sales mgr., Rockwool Divn., Alfred Rogers Ltd., Toronto, Ont.
References: E. A. Allcut, D. S. Lloyd, R. E. Smythe, R. N. Austin.

## FOR TRANSFER FROM THE CLASS OF ASSOCIATE MEMBER TO THAT OF MEMBER

WEBB—HARRY RANDALL, of Edmonton, Alta., Born at Luean, Ont., Jan. 13th, 1900; Educ., B.Sc. (C.E.), 1921, M.Sc. (C.E.), 1922, Univ. of Alta.; R.P.E. of Alta.; 1922-28, lecturer in civil engrg., 1928-32, asst. professor in civil engrg., and 1932 to date, associate professor, in civil engrg., University of Alberta. Engineering experience, mostly during summer periods, includes rodman, dftsman. and instr'man. with the Prov. Govt., Dept. of the Interior, and the C.P.R. Commercial testing, research, and design, for the Dominion Research Council, Calgary Power Company and other companies. (*St. 1919, Jr. 1927, A.M. 1932.*)
References: R. S. L. Wilson, E. Stansfield, H. J. MacLeod, A. W. Haddow, R. J. Gibb, R. W. Ross, C. A. Robb, C. E. Webb, W. R. Mount, F. K. Beach, C. E. Garnett.

## FOR TRANSFER FROM THE CLASS OF JUNIOR

DesBRISAY, ARETAS WILLIAM YOUNG, Capt., R.C.S., of 102 Bagot St., Kingston, Ont., Born at Petit Rocher, N.B., June 4th, 1904; Educ., Grad., R.M.C., 1925. B.Sc., McGill Univ., 1927; Ph.D., Univ. of London, 1937; With the Bathurst Company, Bathurst, N.B., as follows: 1925 (summer), asst. operator, hydro-electric plant, 1926 (summer), instr'man., hydro investigation survey, 1927, instr'man. on prelim. rly. survey, 1928, block line survey, 1928, dftsman; 1928-31, transmission engrg., Northern Electric Co. Ltd., Montreal; 1931 to date, Officer, Royal Canadian Signals, Dept. of National Defence, at present, chief technical instructor, Canadian Signal Training Centre, Barriefield, Ont. (*St. 1926, Jr. 1931.*)
References: D. M. Jemmett, W. L. Laurie, C. Vokes, L. F. Grant, H. H. Lawson.

FARRELL—ALFRED JAMES, of 5088 Cote St. Antoine Road, Montreal, Que., Born at Montreal, May 15th, 1900; B.Sc., McGill Univ., 1924; 1924-26, installn. of rubber flooring, Dominion Rubber Company, Montreal; 1926-28, inspr., Canadian Fire Underwriters Assn., Montreal; 1928 to date, with the Royal Trust Company, Montreal, on repairs and mtce. of rented properties. (*St. 1924, Jr. 1926.*)
References: C. M. McKergow, J. M. Fairbairn, H. W. Lea, A. J. Foy. E. R. Smallhorn, H. J. Leitch, R. S. Logan.

GRANT—ALEXANDER GEORGE, of Red Rock, Ont., Born at Glasgow, Scotland, Dec. 10th, 1903; Educ., B.A.Sc., Univ. of Toronto, 1927; 1925-26 (summers), dftsman., John T. Hepburn Co., Toronto, and Can. International Paper Co. Ltd.; 1927 (7 mos.), dftsman., Roger Miller & Sons, Toronto, 1927-28, dfting, designing, surveying, G. W. Rayner, M.E.I.C., Toronto; 1928-29, asst. engr., Shell Co. of Canada Ltd.; 1929, quantity surveyor and field engr., Russell Construction Co. Ltd., Toronto; 1929-30, field engr., Can. International Paper Co. Ltd., Temiskaming, Que.; 1930-32, dftsman., Ontario Power Service Corpn., Fraserdale, Ont.; 1934-35, designing dftsman., Howard Smith Paper Mills, Cornwall, Ont.; 1935-36, dftsman., struct'l. design and dtting. (4 mos.), asst. engr., rehabilitation of houses (10 mos.), Anglo-Newfoundland Development Co. Ltd., Grand Falls, Nfld.; at present, field engr., mill constrn., Lake Sulphite Pulp Co. Ltd., Red Rock, Ont. (*St. 1927, Jr. 1930.*)
References: W. B. Crombie, L. S. Dixon, A. T. Hurter, P. C. Kirkpatrick, H. E. Meadd, G. W. Rayner, P. Reynolds, R. G. Saunders.

PIDOUX—JOHN LESLIE, of 6891 Sherbrooke St. W., Montreal, Que., Born at Birmingham, England, June 17th, 1902; Educ., B.Sc., Univ. of Alta., 1934, M.Eng., McGill Univ., 1936; 1928-29 (summers), chainman, rodman and dftsman Calgary Power Co.; 1930 (May-Dec.), rodman on rld. location and constrn., Northern Alberta Rlys.; With Main Highways Br., Dept of Public Works, Alta. as follows: 1931, instr'man., on highway location and constrn., 1932, supervising gravel surfacing, 1934-35, instr'man. on highway location and constrn.; July 1936, to date, struct'l. designer, Dominion Bridge Co. Ltd., Lachine, Que. (*St. 1930, Jr. 1935.*)
References: D. B. Armstrong, J. W. S. Chappelle, R. S. Eadie, H. J. McLean, F. Newell, R. S. L. Wilson.

RACEY—HERBERT JOHN, of 256 Trenton Ave., Town of Mount Royal, Que., Born at Chicoutimi, Que., Mar. 29th, 1904; Educ., B.Sc. (Civil), Queen's Univ., 1928; 1925-26-27, rodman, Ottawa Montreal Power Co., field dftsman and instr'man., Shawinigan Engrg. Co.; 1928-30, field engr. on power development and transmission line surveys, Power Engrg. Co.; 1930-31, res. engr. on constrn. of Mattawin River Storage Dam, Shawinigan Engineering Co., and 1931-32, engrg. inspection work on Rapide Blanc development and res. engr. on constrn. of Poisson Blanc storage dam for same company; 1933-35, in mfg. and export business on own account; 1935-36, industrial engr., Crane Limited; at present, asst. mgr., Canadian Potteries Ltd. (subsidiary of Crane Limited). (*St. 1928, Jr. 1931.*)
References: C. S. Saunders, R. E. Heartz, C. R. Lindsey, B. S. McKenzie, W. P. Wilgar.

## FOR TRANSFER FROM THE CLASS OF STUDENT

ALLAIRE—LUCIEN, of 2182 Sherbrooke St. E., Montreal, Que., Born at Montreal, Feb. 16th, 1909; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1935; 8 mos., underground engr. for Tetreault mine; 4 mos., air conditioning for Michel Chouinard Ltd.; at present in charge of field party, surveying lakes, etc., for drainage section, Dept. of Agriculture, Prov. of Quebec. (*St. 1936.*)
References: A. Frigon, S. A. Cyr, G. J. Papineau, O. O. Lefebvre, T. J. Lafreniere, J. A. Lalonde.

BENOIT—JACQUES, of Outremont, Que., Born at Montreal, July 16th, 1909; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1933; 1929-30-31 (summers), rodman and instr'man., Dept. Rlys. and Canals; 1931 (summer) and 1933 (6 mos.), instr'man., A. Janin & Co., Montreal; 1934-36, sales engr., Wallace & Tiernan Ltd.; at present, district sales mgr. for same company. (*St. 1933.*)
References: J. A. Lalonde, E. Gohier, C. C. Lindsay, A. Cousineau, A. Frigon, C. E. Hogarth.

BUCHANAN—EDWARD TREVOR, of 17 Station Ave., Shawinigan Falls, Que., Born at Montreal, April 13th, 1906; Educ., McGill Univ., B.Sc. (Elec.), 1928; 1928-33, commercial engr., dealing with toll line and carrier current equipment, Northern Electric Co. Ltd., Montreal; 1934-35, statistical work re transportation in Canada, L. R. Thomson, M.E.I.C., Montreal; 1935 to date, asst. master mechanic, Consolidated Paper Corpn., Shawinigan Falls, Que. (*St. 1926.*)
References: H. E. Bates, L. R. Thomson, E. B. Wardle, E. Brown, C. V. Christie, R. DeL. French.

CAMPBELL—JAMES STOUFFER, of 288 Braeside Road, Toronto, Ont., Born at Toronto, May 3rd, 1909; Educ., B.Sc., 1931, M.Sc., 1933, Queen's Univ.; 1926-27, ap'tice die and toolmaker, D. A. McCowans, Toronto; 1929 (5 mos.), struct'l. dftsman., 1930 (5 mos), plate and tank dftsman., Dominion Bridge Co. Ltd., Lachine; 1931-33, instructor and demonstrator, mech. engrg., Queen's Univ.; 1931 and 1933 (summers), asst. foreman, and 1933-34, foreman, palmolive and dryer depts., Colgate Palmolive Peet Co. Ltd., Toronto; 1934-35, inspr., Industrial Accident Prevention Assn., inspecting mfg. plants throughout Ontario; 1935 to date, supervisor, pricing and routing depts., Massey-Harris Co. Ltd., Toronto. Responsible for labour costs and estimated cost for production of new machines, and for routing through factory of all parts. Setting of piece work prices and development of standard piece work schedules used for predetermination of piece work prices. Time study work, etc. (*St. 1928.*)
References: A. Peden, L. T. Rutledge, D. S. Ellis, A. Macphail.

EVANS—DELANO ERNEST, of 1466 Mansfield St., Montreal, Que., Born at Quebec, Que., Oct. 13th, 1908; Educ., B.Sc., 1930, M.Eng., 1933, McGill Univ.; 1928-29-30 (summers), dftsman. and designer, struct'l. steel and reinforced concrete bldgs., Dominion Reinforcing Steel Co., Montreal; 1930-31, instructor, McGill Univ.; 1931-32, designer, for Beauharnois Power Co., employed by F. B. Brown, M.E.I.C., also asst. field inspr.; 1934 to date, designer, industrial and mining machy., Dominion Engineering Works, Lachine, Que. (*St. 1930.*)
References: J. F. Plow, J. H. Maude, C. D. Evans, S. S. Colle, L. Jehu.

FRIZZLE—HAROLD ROBERT, of 389 King St. W., Brockville, Ont., Born at Lockeport, N.S., Mar. 16th, 1910; Educ., B.Sc. (E.E.), N.S. Tech. Coll., 1933; 1930 (4 mos.), installn. ap'tice, Maritime Telephone and Telegraph Co., and 1930-31 (11 mos.), mtce. man with same company; 1936 to date, with the Phillips Electric Works Ltd., studying mfg. methods, etc., and at present asst. foreman. (*St. 1935.*)
References: S. Ball, C. A. Anderson, G. H. Burchill, P. A. Lovett, A. D. Nickerson.

GORDON—HUGH JOHN, of Montreal, Que., Born at Winnipeg, Man. Feb. 10th, 1910; Educ., B.Eng., McGill Univ., 1933; 1929 (summer), rodman, Geol. Survey of Canada; 1929-30, dftsman., Fraser Companies Ltd.; 1934 to date, dftsman., C.P.R., Montreal, Que. (*St. 1933.*)
References: J. M. R. Fairbairn, J. E. Armstrong, R. B. Jones, R. Mudge, A. R. Ketterson.

HEENEY—CARDEN THOMAS, of Ottawa, Ont., Born at Ottawa, Sept. 16th, 1904; Educ., B.Sc., McGill Univ., 1926; 1926 (summer), instr'man., Quebec Development Co.; 1926-28, instr'man. i/c survey party, Gatineau Power Co.; With the Corporation of Ottawa as follows: 1928-30, asst. engr., engrg. de pt., 1930-32, asst. engr., water dept., asst. to the res. engr., layout and supervision, constrn. of Ottawa water purification plant; 1932-35, operation of plant, and 1935 to date, res. engr., i/c of the water purification plant and the Lemieux pumping station. (*St. 1927.*)
References: W. E. MacDonald, F. C. Askwith, G. F. Taylor, W. F. M. Bryce, R. E. Hayes.

JOLLEY—MALCOLM PORTER, Lieut., R.C.O.C., of Ottawa, Ont., Born at Foster, Que., Dec. 20th, 1909; Educ., B.Eng. (Mech.), McGill Univ., 1933. Ordnance Mech'l. Engr., Military College of Science, Woolwich, England, 1935; 1930-33 (summers), municipal engrg., Granby, Que.; 1935-36, survey of small arms production in England; 1936 to date, asst. to Director of Artillery and Mechanization, Department of National Defence, Ottawa, Ont. (*St. 1932.*)
References: N. O. Carr, N. C. Sherman, G. R. Turner, C. M. McKergow, A. R. Roberts.

LIND—WALTER JOHN, of 333 Reid St., Peterborough, Ont., Born at Hedley, B.C., Sept. 22nd, 1907; Educ., B.A.Sc., 1932, M.A.Sc., 1935, Univ. of B.C.; 1930-31 (summers), B.C. Photographical survey, and Cons. Mining and Smelting Co.; 1934-37, asst., dept. of mech and elec. engrg., Univ. of British Columbia; at present, student, test course, Can. Gen. Elec. Co. Ltd., Peterborough, Ont. (*St. 1930.*)
References: V. S. Foster, G. R. Langley, W. T. Fanjoy, B. Ottewell, H. R. Sills, L. DeW. Magie.

LUNN—FREDERICK RICHARD, of 458 Argyle Ave., Westmount, Que., Born at Montreal, Mar. 21st, 1905; Educ., B.Sc. (Mech.), McGill Univ., 1929; 1924-28 (summers), machinist's ap'tice, and dftsman.; 1929-33, asst. to manager of G. J. Lunn & Co., Montreal, i/c of design of power punch press and drop hammer tools, dies, jigs and fixtures, cost estimating and manufacturing methods; 1933 to date, manager, i/c of general supervision and management of all operations of the above mentioned company (*St. 1927.*)
References: C. M. McKergow, A. R. Roberts, E. C. Kirkpatrick, C. E. Herd, H. M. Lyster, J. H. Summerskill.

MACPHERSON—DONALD CECIL, of 160 Trenton Ave., Town of Mount Royal, Que., Born at Kingston, Ont., Apr. 1st, 1900; Educ., B.Sc., Queen's Univ., 1924; 1922 (5 mos.), instr'man., Erie barge canal; 1923, concrete inspr., Twp. Scarborough; 1924-29, field engr., Dominion Bridge Co. Ltd., Montreal; 1930, res. engr. for owners, Canadian Potteries, St. Johns, Que.; 1931-37, plant engr., Crane Limited and Warden King Limited; March 1937 to date, factory supt., Canadian Marconi Company, Montreal, Que. (*St. 1922.*)
References: D. S. Ellis, M. S. Macgillivray, W. L. Malcolm, D. C. Tennant, W. P. Murray, W. P. Wilgar.

MANNING—WALTER JOHN, of 3203 Maplewood Ave., Montreal, Que., Born at St. Johns, Que., Apr. 2nd, 1905; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1927; R.P.E. of Que.; 1927-29, traffic dept., Bell Telephone Co. of Canada; 1929-30, engr., Maison Arthur LeBlanc Inc.; 1930-32, constrn. engr., Hopital Notre Dame; 1932-34, constrn. engr., Catholic School Board; 1934-36, roads and bridges engr., Colonization Dept., Prov. of Quebec; at present, res. engr., Dept. of Public Works, Rimouski, Que. (*St. 1929.*)
References: A. Frigon, J. A. Lalonde, J. A. Duchastel, A. B. Normandin, P. L. Kuhring, A. Paradis, A. Gratton, R. deB. Corriveau, L. G. Trudeau.

MURRAY—WILLIAM MACGREGOR, of Cambridge, Mass., Born at Montreal. Apr. 24th, 1910; Educ., B.Eng., McGill Univ., 1932. S.M., 1933, Sc.D., 1936, Mass. Inst. Tech.; R.P.E. of Que.; Summer employment and ap'ticeship during vacations; 1935 to date, instructor in dept. of mech'l. engrg., Massachusetts Institute of Technology, at present i/c of courses in photo-elasticity. (*St. 1932.*)
References: C. M. McKergow, E. Brown, A. R. Roberts, R. Mudge, W. A. Murray.

McQUEEN—DUNCAN RODERICK, of 229 Woolwich St., Guelph, Ont., Born at Oulton Broad, Suffolk, England, Feb. 27th, 1907; Educ., B.A.Sc., Univ. of Toronto, 1932; 1927-28 and summers 1929-30, asst. to hydraulic engr., H. G. Acres & Co., Niagara Falls, Ont.; 1934 to date, with the Canadian Gypsum Co., Guelph, Ont. 6 mos. in office, 6 mos. as mill foreman, and two years to date as quarry foreman, i/c of power shovels removing overburden from limestone, drilling, blasting, breaking, sorting, transportation and hoisting of limestone in kilns; also drawing up plans for future plant operations and general development. (*St. 1930.*)
References: H. G. Acres, R. L. Hearn, C. R. Young, A. W. F. McQueen, R. E. Smythe.

ORR—WALTER ALYN, of Trenton, Ont., Born at Daysland, Alta., Sept. 5th, 1910; Educ., B.Sc. (E.E.), Univ. of Alta., 1932. Officers Signals Course, Cranwell, England, 1936-37; 1932 to date, with the Royal Canadian Air Force on general duties and as a Signals Officer since April 1934; at present, Adjutant, Wireless School, R.C.A.F. Trenton, Ont. (*St. 1932.*)
References: H. J. MacLeod, W. E. Cornish, R. S. L. Wilson, H. B. Godwin, S. W. Coleman.

PAQUET—JEAN M., of 62 Salaberry, Quebec, Que., Born at Quebec, Nov. 27th, 1909; Educ., B.A.Sc., C.E., Ecole Polytechnique, Montreal, 1934; 1930-33, asst. engr., Canadian Construction Ltd.; 1935-36, dist. engr., Prov. Board of Health; 1936 to date, engr., J. A. Y. Bouchard Ltee., heating, air conditioning, refrigeration. (*St. 1934.*) (*R.P.E. of Que.*).
References: T. J. Lafreniere, A. Lariviere, J. Saint Jacques, H. Cimon, A. R. Decary.

PEREGO—HENRY ANTHONY, of 3837 Old Orchard Ave., Montreal, Que., Born at Montreal, Feb. 25th, 1908; Educ., B.Eng., McGill Univ., 1934; 1934-35, industrial engr., Dominion Rubber Co. Ltd.; 1935-36, demonstrator, McGill Univ.; 1936 to date, struct'l. designer, Dominion Bridge Co. Ltd., Montreal, Que. (*St. 1931.*)
References: F. Newell, E. Brown, R. DeL. French, F. J. McHugh, A. W. Whitaker, Jr.

PHILLIPS—ROBERT WESTON, of Chambly Canton, Que., Born at Montreal, Sept. 21st, 1909; Educ., B.Eng. (Mech.), McGill Univ., 1934; 1927-28, rodman and chainman, Candn. International Paper Co. Ltd.; 1928-29 (summers), shipper, Murray Bay Paper Co. Ltd.; 1930 (summer), dfting and mill experience, Ste Anne Paper Co. Ltd.; 1935 (June-Dec.), engrg., Concordia Gold Mining Co.; Jan. 1936 to date, sales service and combustion engr., Bailey Meter Co. Ltd., Montreal, Que. (*St. 1931.*)
References: W. L. Thompson, J. D. Young, L. R. McCurdy, R. DeL. French, A. R. Roberts.

PIMENOFF—CLEMENT JOHN, of 2356 Hampton Ave., Montreal, Que., Born at Barnaoul, Russia, Jan. 7th, 1910; Educ., B.Sc., 1931, M.Eng., 1932, McGill Univ.; 1929-30 (summers), gen. constrn. work, Power Corpn. of Canada and Shawinigan Engrg. Co.; 1931-35, demonstrator, McGill University; 1935 (Jan.-Feb.), asst. computer of stresses in aeroplanes, Noorduyn Aircraft Ltd.; Feb. 1935 to date, struct'l. designer, Dominion Bridge Co. Ltd., Montreal, Que. (*St. 1931.*)
References: E. Brown, R. E. Jamieson, F. P. Shearwood, F. Newell, R. S. Eadie, D. B. Armstrong, M. H. Jones.

ROSE—ALEXANDER, of Ottawa, Ont., Born at Montreal, Que., June 12th, 1912; Educ., B.Eng. (Chem.), McGill Univ., 1935; Summers 1932-33-34, chainman, Technical Service, City of Montreal, rodman, Beauharnois Light Heat & Power Co.; 1935, analyst and inspr., J. T. Donald & Co. Ltd.; 1936 (Feb.-Aug.), timekpr. and metal balance clerk, Canadian Copper Refiners Ltd., Montreal East; Feb. 1937 to date, junior research asst., Divn. of Chemistry, National Research Council, Ottawa, Ont. (*St. 1934.*)
References: E. Brown, F. M. Wood, J. B. Phillips, J. R. Donald, A. G. L. McNaughton, S. S. Colle.

ROSS—DONALD, of 126 Douglas Avenue, Saint John, N.B., Born at Inverness, Scotland, Dec. 18th, 1907; Educ., B.Sc. (Civil), Univ. of N.B., 1937; 1935 (Aug.-Nov.), pile driving, Saint John Harbour for Foundation Co. of Canada; Nov. 1935 to Oct. 1936, and May to Aug. 1937, instr'man. and asst. engr. on same project; 1937 (Sept.-Oct.), field engr. for B. McDonald & Sons, at Price Bros. mill at Riverbend; at present, asst. engr., Price Bros. & Co. Ltd., Riverbend, Que. (*St. 1935.*)
References: J. Stephens, E. O. Turner, A. Gray, R. J. Griesbach, G. F. Layne, N. F. McCaghey.

SMITH—ADAM W. SIMPSON, of 7 Edgewood Crescent, Toronto, Ont., Born at London, Ont., May 20th, 1902; Educ., B.Sc. (E.E.), McGill Univ., 1923; 1923-24, demonstrator, elect'l. lab., Univ. of Toronto; With the H.E.P.C. of Ontario as follows: 1924-26, apprenticeship course; 1926-29, rural supt., and 1929 to date, asst. engr. (*St. 1921.*)
References: H. J. Lamb, O. Holden, W. Maclachlan, W. S. Wilson, J. R. Montague.

THOMAN—RUSSELL KENNETH, of 13 Barnsdale Ave. No., Hamilton, Ont., Born at Hamilton, July 31st, 1910. Educ., B.Sc. (M.E.), Queen's Univ., 1936; 1927-30, steel erection, Hamilton Bridge Ltd.; 1930-33, machy. erection, plant layout, Garden City Press, Ste Annes, Que.; 2 mos., asst. to chief inspr., Allis-Chalmers, Lachine; 1936 to date, with Remington Rand Ltd., Hamilton, as production manager, work includes time studies, assembly layout, prelim. design of jigs and fixtures, methods of manufacture, planning, control of manufacture. (*St. 1936.*)
References: J. E. Goodman, R. A. Low, R. E. Smythe, A. R. Hannaford, A. B. Dove, H. B. Stuart.

WALLACE—KEITH B., of Farnham, Que., Born at Inwood, Ont., Feb. 26th, 1906; Educ., B.Sc., McGill Univ., 1930; With the Dominion Oilcloth and Linoleum Co. Ltd., Montreal, as follows: 1924-29 (with exception of college terms), dfting, 1930-33, asst. supt., printing dept., and 1933-37, asst. supt., tablecloth dept.; at present, chief engr., Barry & Staines Linoleum (Canada) Ltd., Farnham, Que. (*St. 1929.*)
References: A. A. Mellor, J. L. Bieler, C. M. McKergow, E. Brown, A. R. Roberts.

WILKINS—RONALD EDWARD, Lieut., R.C.E., of Esquimalt, B.C., Born at Vancouver, B.C., Dec. 17th, 1913; Educ., Grad., R.M.C., 1935. B.Sc.(Civil), Queen's Univ., 1936; 1935 (summer), School of Military Engrg., Petewawa; 1935-36, attached to D.E.O., Mil. Dist. No. 3; 1936-37, Officer i/c works, Work Point Barracks, and Sept. 1937 to date, Officer i/c constrn., Albert Head Battery, West Coast Defences, Esquimalt, B.C. (*St. 1935.*)
References: W. P. Wilgar, L. F. Grant, H. H. Lawson, H. L. Sherwood.

WINTER—FRANCIS EDWARD, of Montreal, Que., Born at Montreal, Nov. 15th, 1904; Educ., B.Sc., McGill Univ., 1926; 1920-25, outside plant inspr., Bell Telephone Co. of Canada; 1926-28, test course, course in advanced engrg., design, General Electric Company; 1928-29, test course, meter dept., Shawinigan Water & Power Co. and Quebec Power Co.; 1929-33, sales engr. (asst. to vice-pres.), and in 1933 i/c of production, sales, etc. for one divn., Heinz Mfg. Co., Philadelphia, Pa. (*St. 1924.*)
References: J. F. Plow, H. Massue, G. R. Hale, A. S. Runciman, R. H. Mather, W. McG. Gardner.

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The longest bridge in Europe, the two-mile-long Storstrom bridge, Denmark, was opened by King Christian IV of Denmark on September 26th, 1937.

Steel to the amount of 30,000 tons has gone into the making of this $6,250,000 bridge which joins the Danish islands of Falster and Masnedo. Built by Messrs. Dorman, Long & Co. Ltd., of Middlesbrough, England, the bridge has taken four years to complete and carries a single line track of the Danish State Railways, a motor road, a footpath and a cycle-way.

*Courtesy Industrial Britain*

Storstrom Bridge, Denmark.

The safety and convenience of sea-going traffic under the bridge has been allowed for by the provision of three navigation spans, the largest of which has nearly 400 ft. clear width between piers and is over 85 ft. in height. An official estimate of the number of vessels passing through the Storstrom Channel is 15,000 per annum.

The 49 piers of the bridge are built of concrete, with granite facing and cut-waters to withstand the pack-ice, which in the shallows may reach a height of 22 ft. in the Baltic winter, exerting a tremendous pressure.

About 140,000 cu. yd. of concrete and granite were required for the piers and abutments of the bridge, and its deck contains about 12,000 cu. yd. of reinforced concrete.

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STRUCTURAL DESIGNER AND ESTIMATOR, experienced in detailing, checking and designing structural steel. Graduate in civil engineering University of Toronto. At present in Montreal, but location immaterial. Apply to Box No. 613-W.

ELECTRICAL ENGINEER, B.SC., E.E., age 38. Married. Ten years electrical experience; including, one year operation, one year maintenance, and four years on construction of hydro-electric plants and sub-stations. Four years electric maintenance and construction in pulp and paper mill. Also experience on highway construction and Geological Survey Available at once. Apply to Box No. 636-W.

ELECTRICAL ENGINEER, B.SC. E.E. '28. Two years with large electrical manufacturing company including test course, about two years in supervisory operating office of a large electrical power utility, and considerable experience in electrical and mechanical draughting. Location in Ontario preferable. Apply to Box No. 660-W.

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YOUNG CIVIL ENGINEER, B.SC. (Univ. of N.B. '31), with experience as rodman and checker on railroad construction, is open for a position. Apply to Box No. 728-W.

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ELECTRICAL ENGINEER, B.SC. '31, JR.E.I.C. Single. One and a half years with contracting firm installing power and lighting equipment. Four years supervision over service and sales staff of electrical and radio company. Draughting and designing experience in power and compressed air layouts. Estimating and designing for electrical and mechanical layouts desired. Available on short notice. Apply to Box No. 740-W.

CIVIL ENGINEER, S.E.I.C., B.SC. in C.E. (Sask. '32). Single. Age 27. Three years experience includes—instrumentman, compiling reports and draughting with a National Park; in charge of construction of water supply and sanitary sewer systems; assistant on city surveys. Excellent draughtsman. Available at once. Location immaterial. References. Apply to Box No. 818-W.

MECHANICAL ENGINEER, JR.E.I.C., technical graduate, bilingual, age 35, married, experience includes five years with firm of consulting engineers, design of steam boiler plants, mechanical equipment of buildings, heating, ventilating, air conditioning, plumbing, writing specifications, etc. Five years with large company on sales and design of power plant, steam specialties and heating equipment. Available on short notice. Apply to Box No. 850-W.

STRUCTURAL ENGINEER, B.A.SC., A.M.E.I.C. Twenty-two years experience in design of bridges and all types of buildings in structural steel and reinforced concrete. Three years experience in railway construction and land surveying. Apply to Box No. 856-W.

ELECTRICAL ENGINEER, B.SC. (McGill '28), age 34. Experience includes transmission line and rural distribution construction and design. Some installation of motors and equipment, also house wiring. Available immediately. Apply to Box No. 940-W.

ENGINEER SUPERINTENDENT, age 44. Engineering and business training, executive ability, tactful, energetic. Had charge of several large projects. Intimate knowledge of costs and prices, reports and estimates. Available immediately. Any location. Apply to Box No. 1021-W.

ELECTRICAL ENGINEER AND GEOPHYSICIST. B.SC. (Man. '23), A.M.E.I.C. Married. Ten years specialized experience in the practical use of magnetic, electrical and mechanical instruments for the prospecting, surveying and mapping of mineral, oil and gas lands. Five years experience with telegraph, telephone and radio equipment. Capable of giving instruction in theory and practice in these lines and in college physics. Available on short notice. Apply to Box No. 1063-W.

CIVIL ENGINEER, A.M.E.I.C., with over twenty years experience in field and office on construction, maintenance, surveying, location, etc., desires position preferably of a permanent nature. At present near Montreal, but willing to locate anywhere. Apply to Box No. 1168-W.

ELECTRICAL ENGINEER, B.SC. '34 (Univ. of N.B.), S.E.I.C. Age 24, single. Desires any kind of electrical work. Will consider any location. Apply to Box No. 1262-W.

ELECTRICAL AND RADIO ENGINEER, S.E.I.C., B.SC. (Elec.) '32, M.SC. '34. Experience includes four years part time operator for radio broadcast station, repairs to radio receivers and test equipment, design and construction of amplifiers and inter-office communication systems. Available on short notice. Apply to Box No. 1283-W.

CIVIL ENGINEER, M.E.I.C., R.P.E., married, age 40. Twenty-two years experience in detail, design, estimating and cost accounting of buildings, bridges, tanks and all types of structures,; organization and management. Apply to Box No. 1367-W.

CIVIL ENGINEER, B.SC. 1910, A.M.E.I.C. Married. Twenty-six years experience on heavy construction work, both field and office; rails, roads, power house, hotels, bridges, etc. Location immaterial. Available at once. Apply to Box No. 1470-W.

## Situations Wanted

CONSTRUCTION SUPERINTENDENT, M.E.I.C. Ag 49. Married. Twenty-two years experience as engineer, superintendent and manager in charge of hydro-electric mechanical production, structural steel erection, als considerable experience in steam plants, combustion transmission lines, millwright work, complete min installations, rock work, rock crushers and conveyors Executive ability. Speaking French fluently. Location immaterial. Apply to Box No. 1482-W.

ELECTRICAL ENGINEER, B.Eng. (McGill '33). One and a half years experience in plant and production routine, and with considerable training in sales work. Bilingual, single, and available at once for any location. Apply to Box No. 1509-W.

ELECTRICAL ENGINEER, B.SC. '31 (Univ. of Alta.), JR.E.I.C. Age 28. Married. One year students' test course with C.G.E.Co. including testing and operation of transformers, meters, industrial control and switchgear apparatus. Two years as instrumentman on highway construction. Desires electrical utility, commercial lighting or air conditioning work, location immaterial and available at once. Apply to Box No. 1522-W.

CIVIL ENGINEER, B.SC. '32, S.E.I.C., P.E.N.B., DY.L.S.N.B., age 32. Experience in mining, both coal and metals, private and legal surveys, railroad construction, geology and building construction. At present in private practice in coal mining district. Desirous of changing location for position either in mining field or construction in Canada. or abroad. Apply to Box No. 1562-W.

RESIDENT ENGINEER, familiar with all types of surveys and construction work including, railway, roads, irrigation, drainage, buildings and air ports. Executive ability. Had charge of several large projects. Intimate knowledge of reports and estimates. Available immediately. Any location. Apply to Box No. 1567-W.

CIVIL ENGINEER, B.SC. '17, O.P.E. Married. Executive and administrative experience. Extensive office and field experience in harbour works, dredging; both steam and electric railways in location, construction and maintenance; telephone works in design, construction and maintenance of pole lines, wire, cable and conduit; highways in location, construction and paving; municipal works in roads, sidewalks, sewers and water mains. Intimate knowledge of estimating, unit costs, cost accounting and analysis. Some knowledge of air conditioning. Willing to locate anywhere. Available at once. Apply to Box No. 1587-W.

ELECTRICAL ENGINEER, B.SC. '27 (McGill), A.M.E.I.C. Age 36. Married. Bilingual. Three years experience in telephone work (installation of manual and automatic exchanges). One year electrical prospecting. Nine years experience with electrical power company. Apply to Box No. 1601-W.

CHEMICAL ENGINEER, graduate McGill '36. Eight months experience in commercial laboratory of large industrial plant. Knowledge of coal chemistry and boiler water treatment. Also some experience in pulp and paper control work. Location immaterial. Apply to Box No. 1617-W.

CIVIL ENGINEER, B.SC. in C.E., A.M.E.I.C. Age 32. Married. Three years of pulp and paper mill experience, draughting, instrumentman and maintenance. One year as instrumentman on highway construction. Five years checking and designing reinforced concrete and steel. Apply to Box No. 1658-W.

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MECHANICAL AND ELECTRICAL ENGINEER, age 47, graduate University of Toronto, 1911. Machinist's trade. Two years tool design and quantity production in the U.S.A. Twelve years Canadian shop experience design and producing heavy equipment. Twelve years as chief sales engineer and field man for one of the largest Canadian national concerns. Experience in manufacturing and sales of pumps, engines, paper mill equipment, power plant equipment and specialties, electrical machinery etc. Clean record, excellent connection. Apply to Box No. 1699-V.

ELECTRICAL ENGINEER, B.SC., E.E. (Univ. of Man. '37). Experience in highway construction as inspector. Available at once. Apply to Box No. 1703-W.

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